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The Glasgow Naturalist

Journal of The Glasgow Natural History Society

Volume 26 Part 1 2014

Including Conference Proceedings: Natives, Aliens and Reintroductions 2013





Glasgow Natural History Society (formerly The Andersonian Naturalists of Glasgow)

The Glasgow Natural History Society is a registered charity (SCO 12586) with approximately 250 members living in Glasgow, the West of Scotland, throughout the UK and overseas. The Society arranges a full programme of events throughout the year in Glasgow and district and occasionally further afield. These are at both specialist and popular level, designed to bring together the amateur and the professional, the expert and the beginner.

The Society has its own library, and provides grants for the study of natural history. Further details about the Society can be found at www.gnhs.org.uk or by contacting the Secretary, The Glasgow Natural History Society, c/o Graham Kerr (Zoology) Building, University of Glasgow, Glasgow, G12 8QQ, Scotland (E-mail: info@gnhs.org.uk). The Society has microscopes and some field equipment that can be used by members. Please contact the Membership Secretary Mr Richard Weddle at the address above for further details.

The Glasgow Naturalist

The Glasgow Naturalist is published by the Glasgow Natural History Society ISSN 0373-241X. It was first issued in 1908-9 and is a peer reviewed journal that publishes original studies in botany, zoology and geology, with a particular focus on studies from the West of Scotland. For questions or advice about submissions please contact the Editor: Dr Dominic McCafferty (E-mail: dominic.mccafferty@glasgow.ac.uk), Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow, Graham Kerr Building, Glasgow G12 8QQ, Scotland. Advice to contributors is given on the inside cover of this edition. The publication is included in the abstracting and indexing of the Bioscience Information Service of Biological Abstracts and the Botanical Society of the British Isles Abstracts. Back numbers of the journal may be purchased by contacting the Society at the address above. Full details of the journal can be found at www.gnhs.org.uk/gnat.html

Publications of the Glasgow Natural History Society

The Society has published a number of books on the flora and fauna of the West of Scotland. Full details can be found at www.gnhs.org.uk/publications.html

Front cover

Red Kite (*Milvus milvus*) in flight at Tollie Red Kites - a partnership between RSPB Scotland and the Brahan Estate. Red Kites have been reintroduced to Scotland, and supplementary feeding is provided in at least four locations in Scotland - Tollie in Easter Ross, Argaty near Doune, Garlogie and Echt in Aberdeenshire and near Loch Ken in Galloway. Image by David Palmar, www.photoscot.co.uk

Back Cover

Eurasian beavers (*Castor fiber*) Elaine and Eoghann emerging from crates on Knapdale loch on 23 June 2010 as part of the Scottish Beaver Trial. The trial has been conducted by The Royal Zoological Society of Scotland and the Scottish Wildlife Trust since 2009. Image Credit: Scottish Beaver Trial.

The Glasgow Naturalist

Volume 26 Part 1

Edited by: Dominic J. McCafferty, John Hume & Iain Wilkie

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EDITORIAL

The climate is right for natural history

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There is growing certainty that anthropogenic factors are contributing to the increased frequency of extreme weather patterns (IPCC 2014). In 2013 the UK had its warmest summer since 2006 and it was drier than average over the last 30 years (MET office 2013). However, this was followed by one of the stormiest and wettest winters on record (MET Office/CEH 2014). With a predicted greater frequency of storms, increased rainfall and rising temperature what can we expect to see happening to our flora and fauna in Scotland? Not surprisingly, considerable effort has recently been given to understanding changes in biodiversity attributed to climate (CEH 2014). Much of this work has centred on measuring phenological changes in the environment. Observations on seasonal phenomena go back a long way, well before Linnaeus recorded the first dates of leafing, flowering and leaf fall. In Scotland systematic phenological records date back to the 1850s, when the Curator, James McNab of the Royal Botanic Garden Edinburgh first recorded the flowering dates of more than 60 plants (Harper *et al.* 2004). More recent studies for example, have shown that there has been an advance of spring leafing by six days and delay of leaf fall by five days since the 1960s; timing of egg laying in great tits (*Parus major*) has advanced by almost four days per decade since the 1970s; and phytoplankton blooms are earlier by more than five days per decade from 1960 onwards in Scotland (Mackey *et al.*, 2001; Sparks *et al.* 2006). These records also provide valuable information on the impacts of extreme weather such as winter storms and periods of drought on mortality and reproductive success. This can identify vulnerable species and may allow appropriate management and mitigation to be implemented.

Many of our long term biological data sets are gathered by naturalists. Phenological records continue to be required and there are a number of national recording schemes for you to submit your records: <http://www.naturescalendar.org.uk/>.

The Biological Records Centre <https://www.brc.ac.uk/> provides the national database for terrestrial and freshwater records and supports UK recording schemes. Naturalists also play a key role in documenting the appearance and fate of new species, see: *Proceedings of the Conference on Natives, Aliens and Reintroductions* (this volume).

In the face of extreme weather events and continued environmental change there is obviously a continuing need for good naturalists with the expertise to identify and record both common and rare species. Concerns have been expressed as to the future of plant recording given that botany degrees are no longer offered at UK Universities (see article: *Death knell sounds for botany degrees*. The Garden January 2012). Animal species that are taxonomically difficult to identify may similarly be neglected. The 'climate' is certainly right for natural history and long may it flourish.

ACKNOWLEDGEMENTS

The Glasgow Naturalist would not be produced without the hard work of many people, including the anonymous reviewers who ensure the scientific quality of this journal. I am particularly grateful to our assistant editors John Hume and Iain Wilkie, Bob Gray for book reviews and to Richard Weddle for making journal articles available online. Many thanks to Kirsteen McColgan who provided considerable assistance with the final printed edition.

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PROCEEDINGS OF THE CONFERENCE

Natives, Aliens and Re-introductions: Opening Remarks

Roger Downie

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I would like to welcome delegates to our conference on behalf of all the organising team which included representatives from GNHS, Glasgow Science Festival, Glasgow City Council, Glasgow Museums, SWT, RSPB, Froglife and the University of Glasgow. I would like to thank all for their work in putting the meeting together, but especially Richard Weddle who bore the brunt of a huge amount of work with remarkable cheerfulness.

We started thinking about a theme for this conference back in the summer of 2011. It seemed a good idea to run a follow-up to our successful 2001 conference on 'Alien species: friends of foes?' which was the centrepiece of GNHS's 150th anniversary celebrations (full proceedings published as *The Glasgow Naturalist* 23 supplement 2001, 113 pp). We noticed that the British Ecological Society (BES) was planning to celebrate its centenary in the summer of 2013 by means of a nationwide Festival of Ecology and had announced a competition for organisations who wished to take part in the festival. It therefore seemed sensible to make a funding application to this competition and we broadened the theme to *Natives, Aliens and Re-introductions: how does ecology inform wildlife conservation in Scotland?* The main components of our contribution to the Festival were to be a two day conference, a schools poster event and themed excursions through the summer. Our application was submitted in December 2011 and success was notified in March 2012, along with two other Glasgow events, the Alexander Wilson bicentenary celebrations (in Glasgow and Paisley, his birth town) and a rainforest exhibition in Kelvingrove Museum and Art Gallery. Serious planning for our contribution began in April 2012 and included approximately monthly meetings with partners and a meeting in October with Julie Hodgkinson of the BES for an overview of all the Festival of Ecology events in Scotland.

An issue for us was the date. We were keen to be part of Glasgow Science Festival as well as the Festival of Ecology, but technically this ended just before the Festival of Ecology started. We wanted to include a schools event, which meant mid to late June at the latest and even if this was separated in time from the conference, we did not want to have a conference in summer holiday time. Since the Alexander Wilson University of Glasgow event got fixed for 14th June, we decided on the following weekend for our conference, and Glasgow Science Festival kindly agreed to include us in their programme, despite being late. By happy coincidence Scottish Natural Heritage declared 2013 the Year of Natural Scotland, so our event fits under three headings.

The issues facing natives, aliens and re-introductions in the context of wildlife conservation are current, relevant and contentious, as I'm sure these two days of talks and workshops will demonstrate. As a taster, here are some recent research paper titles from conservation-related journals:

- Will extreme climate events facilitate biological invasions (*Frontiers in Ecology & Environment* 10, 2012).
- How successful are plant species re-introductions? (*Biological Conservation* 144, 2011).
- Dying for conservation: eradicating invasive alien species in the face of opposition (*Animal Conservation* 13, 2010).
- Assisted colonization: evaluating contrasting management actions (and values) in the face of uncertainty (*Trends in Ecology & Evolution* 24, 2009).
- Translocation or bust: a new acclimatization strategy for the 21st century (*Trends in Ecology & Evolution* 26, 2011).
- Impacts of biological invasions: what's the way forward? (*Trends in Ecology & Evolution* 28, 2013).
- Towards a more balanced view of non-native species (*Conservation Biology* 26, 2012).

- Do invasive species perform better in their new ranges? (*Ecology* 94, 2013).
- The elephant in the room: the role of failed invasions in understanding invasion biology (*Oikos* 122, 2013)
- Protected areas act as establishment centres for species colonizing the UK (*Proceedings of the Royal Society* 280B, 2013).
- The history of public participation in ecological research (*Frontiers in Ecology and Environment* 10, 2012).

I would like to thank all our funders who have made it possible to make this conference almost free entry, especially the British Ecological Society, the Glasgow Science Festival, Glasgow City Council and GNHS's Blodwen Lloyd Binns bequest.

Now, I have pleasure in introducing Julie Hodgkinson who will give us a brief account of the background to the BES Centenary Festival of Ecology.

Civic Reception Natives, Aliens and Reintroductions Conference: University of Glasgow, 22 June 2013

Bailie Nina Baker

Ladies, gentlemen and distinguished guests, it is my great pleasure to welcome you to Glasgow on behalf of the lord provost and people of Glasgow. And it is always a pleasure to come to this little haven of zoology that is one of the city's lesser-known secrets.

I am delighted to give the civic welcome to the Natives, Aliens and Re-introductions conference. Although your conference is part of the British Ecological Society's centenary programme across the country, it has been co-ordinated by Glasgow Natural History Society which is very much older than the BES, having celebrated its 150th birthday a dozen years back. I would also like to thank the work of the council's own staff from Glasgow Museums and Land and Environmental Services, as well as the support provided by the RSPB, SWT, Froglife and the University of Glasgow.

I understand you have had a fascinating range of talks today on a wide range of animals and plants from all three of your categories – badgers and knotweed, beavers, hoverflies and birds. All beautiful parts of nature in their own rights but not necessarily welcomed by everyone in every place. Your posters have covered an even wider range of species and families. And I see that tomorrow you venture out into the highly controlled environments of our local greenspaces and will even be discussing the untamed wilds of policy-making.

Although your conference covers areas well beyond the plant kingdom, it is very appropriate that it is being held at Glasgow University, as the Bower building across the way commemorates one of the university's great professors of the past – Frederick Bower – who had it built and thus established Britain's first botanical institute and some of the most advanced research facilities of the time in the country.

The City very much values the benefits which conferences such as yours bring to the city, both directly through bringing more visitors to enjoy the sights and places of interest, but also indirectly through the development of links and relationships between academia and industry and indeed the general public, which ultimately lead to benefits for the whole of society. So I am pleased to join the organisers in thanking the British Ecological Society for their financial support which has enabled costs to be kept to a minimum so that the widest possible range of participants can attend. Thank you.

Natives, Aliens and Reintroductions Conference 22 – 23 June 2013

Saturday 22 June 2013

10:00 Welcome: Vice-President of GNHS (Roger Downie) & Keynote Statement: Julie Hodgkinson (BES)

Chair: Toby Wilson

10:15 Chris Smout (University of St Andrews): What's natural? A species history of Scotland in the last 10,000 years? The concept of natural is a matter of shifting definition, and what is considered native or alien also depends on definition, history and conjecture. Some groups of species are more likely than others to have a large percentage of

aliens. Dealing with them demands not dogma but a sense of proportion.

11:00 Stan Whitaker (SNH): Moving species around – risks and benefits

The law in Scotland prevents the release and spread of all non-native species. However, only a proportion of non-native species become invasive and many contribute positively to our lives. We may also wish to re-introduce former natives. Which species do we let in and which to we want to keep out?

11:40 Colin Adams *et al.* (SCENE): Introductions as a conservation tool; case studies from rare freshwater fishes in Scotland

With a wealth of supporting exemplars from around the world, it is almost self-evident that the introduction of a species into a habitat that is outside its normal range is likely to be at least negative, but very frequently disastrous, for the receiving ecosystem. Recently however, introductions of some species to new habitats have been used as a conservation management tool. In this talk, the authors explore how translocations are being used in conservation “Ark” sites and the potential benefits they might bring, using case studies from rare freshwater fish species in Scotland.

12:15 Jim Dickson (University of Glasgow): What We Should Do About Japanese Knotweed?

The demonisation of Japanese Knotweed has produced inappropriate control measures which stem more from a combination of emotion, scare-mongering journalism and vested interests than they do from good science. What is needed is a change of attitudes and a new pragmatism with rigorously applied, well thought out and narrow aims to replace the waging of spendthrift wars of attrition. Such wars are ultimately futile in that most or all of the invasive non-native plants are here to stay.

12:40 Lunch in the Zoology Museum and poster-viewing in the laboratory

Chair: Chris Smout

13:40 Toby Wilson (RSPB): The Clyde Valley Wader Initiative – how applied ecology is informing the conservation of farmland waders in S Lanarkshire

The Upper Clyde Valley (including the Duneaton, Medwin and Elvan Waters) continues to hold regionally important populations of farmland waders such as lapwing and redshank. The talk will focus on how the Clyde Valley Wader Initiative seeks to maintain and increase these populations

through targeting funding to landowners to undertake ‘wader-friendly’ farming practices, which are informed by the latest research into wader ecology.

14:00 Ellen Rotheray (University of Sussex): Restoring endangered hoverflies: the pine *Blera fallax* and aspen *Hammerschmidtia ferruginea* hoverflies in Scotland

Conserving these endangered, saproxylic hoverflies requires a detailed understanding of their requirements, ecology and behaviour. Only based on such data can techniques to halt decline and instigate recovery be identified and promoted to landowners and managers. Detailed investigation into adult and larval requirements has uncovered critical new data for developing management protocols for these flagship species, which are among the first hoverflies anywhere to be the target of tailored conservation action. These discoveries and prospects for their successful conservation will be discussed.

14:20 Lorna Cole *et al.* (SRUC): Wild pollinators: Safeguarding populations in intensive agricultural landscapes

There is mounting evidence that wild pollinators are in decline worldwide. With their decline threatening the stability of pollination in both commercial crops and wild plants, this decline has implications to global food security and biodiversity. SRUC are evaluating the importance of a range of farmland habitats for pollinators to identify how populations can be promoted in intensive agricultural landscapes.

14:40 Robert Coleman (RSPB): Giant Docks and Tiny Dinosaurs

RSPB Loch Lomond is set within the Loch Lomond NNR. This is a site with an amazing variety of wildlife, sitting on the edge of the Highlands. How do we manage for this variety and what challenges will there be along the way?

15:00 Roisin Campbell-Palmer (RZSS): Bringing Beavers Back

Reintroducing beavers to Britain is not a new concept. Although most progress has occurred in Scotland, the decision to fully restore this species has still been deferred. With the official scientific trial reintroduction entering its final year and a large, unlicensed population established, the future of beavers in Scotland will ultimately be a political decision and undoubtedly influence their restoration to Britain.

15:20 Break

Chair: Roisin Campbell-Palmer

15:40 Andy Riches (Scottish Badgers): The Badger, Vermin or Victim?

The Eurasian Badger (*Meles meles*) is a native species currently facing a number of threats. In England there are Government plans to allow a cull in an attempt to reduce the spread of Bovine tuberculosis, while the problem of criminal persecution remains a U.K. wide police priority. This presentation will provide an ecological perspective on the situation.

16:00 Richard Sutcliffe (Butterfly Conservation): Conserving the Chequered Skipper

Since its extinction in England in 1976, the Chequered Skipper butterfly now only occurs in the UK in western Scotland. Recent records are restricted to within a 30 mile radius of Fort William. However, recent research predicts that the current distribution of the butterfly may be underestimated by around 20% at a 10km square resolution and possibly by as much as 400% at a 1km scale. Surveys carried out in 2012 revealed previously unknown colonies in some of the top 100 1km squares predicted by the research. Further targeted surveys will help to establish the true distribution of this species, which is a Conservation Priority Species. Similar research in the future could be applied to other species, such as the Pearl-bordered Fritillary.

16:20 Stephen Woodward (University of Aberdeen): Alien invasive pests and pathogens: threats to our native forest ecosystems

UK forests face unprecedented challenges from the influx of alien invasive pests and pathogens resulting from increased global trade. The threat posed by these organisms to individual tree species, to forest biodiversity and to human requirements of forests will be illustrated using examples from Europe and elsewhere in the world.

16:40 Stuart Brabbs (Ayrshire Rivers Trust): Invasive weed control in the Riparian Environment

Invasive non-native plant species in the riparian environment reduce water quality through erosion, restrict access, threaten native biodiversity and can pose significant health risks to human beings. Effective control and eradication relies on a strategic and sustained approach using best practice and the latest technologies available. Whilst not universally popular, the use of herbicide may be seen as an essential component of effective control, although alternatives are available for some species.

17:00 Zara Gladman (Clyde River Foundation): "A tale of two crayfish in Scotland"

There are two non-native crayfish species in Scotland: the white-clawed crayfish (*Austropotamobius pallipes*), which is endangered in its native European range; and the North American

signal crayfish (*Pacifastacus leniusculus*), which is considered a serious threat to native biodiversity. Recent research has investigated the status and impact of these species in Scotland and will be presented here.

17:20 Summing-up: Roger Downie (GNHS), and Civic Reception in the Zoology Museum

Sunday 23 June 2013: Workshops (10:00, 11:00, 12:00)

Emma Downie (Froglife): Translocations for Conservation: Good, Bad or Both?

The practice of translocating rare or threatened species is increasingly being used in the conservation of our native flora and fauna. The technique is used to safeguard species against development, help repopulate species' historical ranges, and establish 'ark' populations. There are both positives and negatives to this approach and this workshop will investigate and discuss the approach through examination of case studies from the UK and abroad.

Toby Wilson (RSPB): Ecological management of a (fictitious) reserve

Nearly all nature reserves in the UK require some form of management. The workshop will examine some of the issues faced by reserve managers, focussing on a fictitious reserve where native, alien and reintroduced species have to be considered.

Ken Neil (Scottish Squirrel Survey): Saving Scotland's Red Squirrels

Red squirrels in Scotland and the wider UK are under threat from a number of directions, not least the spread of invasive grey squirrels. Saving Scotland's Red Squirrels is a project that brings together expertise and experience from a range of individuals and organisations in a bid to safeguard their future. This workshop will discuss the practical work of the project and its strategies.

Keith Watson (Glasgow Museums): Alien Plants: what are they doing and what should we be doing?

Alien plants are widespread, particularly in urban floras, but there is little hard evidence as to their real impact on the local ecology or nature conservation. A few examples will be explored and discussion encouraged to find out more about the role alien plants are playing. Importantly can we, or should we, do anything about them?

Roger Downie (University of Glasgow): Can ethical analysis contribute to policy and practice development in wildlife conservation?

Wildlife conservation is partly a science, but as soon as we ask what should be conserved, how and why, our answers are influenced by ethics. In animal conservation, a major factor is welfare and a confounding variable can be human perceptions of the value of particular species. An obvious contrast is people's reactions to the culling of hedgehogs on the Western Isles compared to rats on Ailsa Craig, in both cases mainly to protect nesting birds. This workshop will introduce a method of ethical analysis and participants will then use it on cases relevant to aliens and reintroductions.

Lunch: bring your own, or go to nearby shops / cafés; (poster-viewing; teas coffees etc available).

Afternoon Excursions

Keith Watson: Kelvingrove Park to Botanic Gardens

Starting at the Kelvin by Partick Bridge and heading upstream (south/east bank) past Kelvingrove Museum and through the park; then under Kelvinbridge towards the Botanic Gardens along the mill lade.

Roger Downie & Bob Gray: GU Campus, Botanic Gardens Arboretum and Bingham's Pond

Glasgow West End eco-Walk: this will take us via the University Wildlife garden and the Botanic Gardens, then along the Kelvin walkway/arboretum, finishing at the naturalised Bingham's pond. Many chances to observe urban wildlife, natives and aliens.

Posters

Brian Boag: The New Zealand flatworm, Scotland's unwanted alien visitor

The New Zealand flatworm (*Arthurdendyus triangulatus*) was first recorded from Scotland in 1965 and is now widely distributed. It is an obligate predator of our native earthworms. In farmland this can result in poor drainage and reduced crop-yields; where moles were once plentiful now there are none, and the detrimental impact on other animals e.g. badgers, hedgehogs, shrews and birds is unknown.

Mike Davidson: Life in a Scotch Cemetery

The chance discovery of a colony of North American spiders at the Glasgow Necropolis, led to an investigation of the invertebrate fauna of this important green-space. Survey findings are presented and some non-native species are discussed in relation to the native fauna. The wildlife potential of Scottish burial-grounds is greatly undervalued and opportunities for improved management are considered.

Helen Downie: Water vole reintroduction in Ayrshire

After becoming locally extinct, Ayrshire Rivers Trust conducted a lowland reintroduction of water voles (*Arvicola amphibius*) to an area of prime habitat. Animals were sourced from upland Ayrshire and Lanarkshire and captive bred to produce a population of local genetic stock. This population was released in 2011 and supplemented in 2012; meanwhile mink were monitored and controlled in the area. Reproduction in the wild population has been confirmed and field sign surveys suggest continued success.

David Palmar: Murder in the Eyrie –a behaviour study of a native species

Golden Eagle Photographs by Charles Eric Palmar. CE Palmar was the Curator of Natural History in the Kelvingrove Art Gallery and Museum from 1949 to 1984; he was also a member of GNHS. His main interest was birds, and he concentrated on Golden Eagle study and photography. The display is a selection of his photos, and show the older eaglet attacking and killing the younger one, taken in Argyllshire in 1956 and 1957.

Chris Cathrine: Grass Snakes in Scotland

Although Scottish grass snake (*Natrix natrix*) records are included in atlases and on NBN Gateway, the accepted view is that this species does not occur in Scotland. However collation and verification of existing data demonstrates that grass snakes occur in Scotland, and may have been present historically.

Katie Thomson: Maerl

The hard twig-like pink nodules of maerl can easily be mistaken as coral. These free-living red seaweeds are capable of incorporating calcium carbonate into their skeletal structure. Maerl grows on the sea bed and where ideal conditions prevail it can form extensive beds; those found in Scotland are amongst the most extensive in Europe. Maerl is extremely slow growing and forms a very fragile three-dimensional habitat and ecosystem associated with a wide variety of plants and animals. Being so delicate maerl is easily damaged by fishing methods such as bottom trawling and dredging.

James Thorburn et al.: Spatial ecology of Spurdog (*Squalus acanthias*) on the west coast of Scotland

Spurdog (*Squalus acanthias*) are small dogfish distributed worldwide. It's unclear if spurdog in the NE Atlantic form one large population or several smaller sub populations displaying regional residency as shown in other parts of the world. It's important that this spatial information is obtained for effective management of the species.

John Hume: Taxonomy, ecology & conservation of Scotland's lampreys

Lampreys are an ancient group of vertebrates consisting of just 43 currently recognised species globally. Scotland contains populations of three lamprey species, two of which (European river and brook lamprey) do not constitute discrete taxonomic entities; morphologically, genetically or behaviourally. However, populations of both currently enjoy very different levels of conservation protection. Scope exists though for protecting such intra-specific diversity within Scottish conservation legislature following designation as Evolutionarily Significant Units. An overview of lamprey diversity and current conservation legislation in Scotland is provided.

Chris McInerny: Observations on a colony of Adders, Slow-worms and Common Lizards on Loch Lomondside, Scotland

A colony of reptiles on the east shore of Loch Lomond, Scotland, was monitored intensively during 2012, to understand population numbers, distribution, movements and biology through the year. Large numbers of European Adders *Vipera berus*, Slow-worms *Anguis fragilis* and Common Lizard *Zootoca vivipara* were detected. Animals were seen throughout the year, first emerging from hibernation in early March and watched until late October, with breeding biology and movements observed.

Julie Nati: Invasive versus native freshwater fish species: Who wins in a changing environment?

The introduction of exotic species into aquatic habitats is a world-wide problem which is predicted to worsen in response to global climate change. In the United Kingdom, for instance, 47% of the freshwater fish species are non-native. Invasive freshwater fish species in Scotland might have wider thermal optima for optimising their aerobic scope than native fish species and invasive fish species which have not invaded Scotland yet. Wider thermal limits will allow invasive species to outcompete native species at higher temperatures (foraging, habitat exclusion, predator avoidance). I will address these questions by studying the physiological and behavioural responses to temperature variation in several native and invasive species in freshwater bodies of the northern United Kingdom.

Hannah Watson et al.: The effects of human disturbance on a small cavity-nesting seabird

While there is wide evidence for adverse effects of human disturbance on animals living above the ground, it is often assumed that burrow-/cavity-dwelling species are less vulnerable to the presence of human activities above ground. We quantified the effects of human disturbance associated with tourism on reproductive behaviour and postnatal

development in the European storm petrel *Hydrobates pelagicus* at a colony in the Shetland archipelago. Despite their nocturnal habits and nesting out of sight, we found that storm petrels breeding in areas of high visitor pressure suffered reduced reproductive success in both a 'good' and a 'poor' year for overall colony productivity. Different patterns of postnatal growth of surviving nestlings were shown between nests exposed to high and low disturbance. An integrated understanding of the effects of human disturbance is essential for informing visitor management at seabird colonies.

Ann-Marie MacMaster: Scottish Mink Initiative

The American mink, *Neovison vison*, is an invasive non-native species which was brought to the UK from North America for the fur-farming industry. Many animals escaped or were released by animal activists, and in 1938 the first mink living wild in the UK were recorded. American mink are a generalist predator and have a devastating effect on our native wildlife, such as ground nesting birds and watervoles.

Our aim is to secure multiple adjacent river catchments as areas free of breeding American mink by monitoring for, trapping and dispatching American mink, thus protecting native wildlife as well as economically important populations of fish and game birds.

Caroline Millins: How does an introduced vertebrate host species affect the risk of Lyme disease? Characterising Grey squirrels (*Sciurus carolinensis*) as tick hosts and reservoir hosts of *Borrelia burgdorferi* s.l. in Scotland

The introduction of a competent reservoir species such as the grey squirrel may modify local disease dynamics and increase the risk of Lyme disease to humans, by increasing the number of infected ticks in an area. The objectives of this study are to quantify and characterise the tick parasite community of grey squirrels, characterise natural infections in grey squirrels and quantify the *Borrelia* prevalence by using organs and xenodiagnosis (pooled larvae from an individual host).

Lyn Dunachie et al.: Friends of the River Kelvin

The Kelvin provides a unique natural environment in the heart of the city. Friends of the River Kelvin was founded over 20 years ago to facilitate responsible enjoyment of the river. Invasive species have spread along the banks, overwhelming native species and damaging habitats and property. Attempts to gain approval to control this are often met with objections. FORK encourages people to learn about and play a part in the care and understanding of the river and its surroundings.

Valerie Semple et al.: Friends of Glasgow's Local Nature Reserves

Glasgow has 10 LNRs, two of which are shared with neighbouring Local Authorities; and several more are in the planning stage. The 'Friends' group exists to raise awareness of the City's LNRs and wildlife; lobby Glasgow City Council to ensure that this environmental resource is protected, managed and enhanced; engage with the Council and others to promote partnership working; organise and support practical conservation days or events in the City; and to raise funds for specific projects.

FULL PAPERS

What's natural: a species history of Scotland in the last 10,000 years

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ABSTRACT

The question of what is natural is considered, and a mismatch is pointed out between the view that man is part of nature and the view that 'natural' means all living things apart from man. The history of man's ability to change the environment of Scotland is briefly outlined, with reference to climate history and some recent modifications to the view that man reduced Scotland to a 'wet desert'. The distinction between native and alien is traced to the Victorians, but it did not become set in stone until after the Second World War. The history of mammals is discussed with particular reference to island races, and to the varied history of the red squirrel and attitudes towards it. In the case of birds, some that are not alien can still be almost entirely dependent on man. Plants are divided into archaeophytes and neophytes depending whether or not they arrived before 1500, and some archaeophytes are now protected. There is brief mention of insects, fungi, the carriers of plant diseases and aquatic organisms. Globalisation has been the greatest carrier of alien species, but only a few have proved invasive.

INTRODUCTION

In 2012, Prince Charles wrote a foreword to Plantlife's booklet, *Our Vanishing Flora*, deploring the destruction of native biodiversity. He said "progress has completely disconnected us from the natural world, so that we no longer appreciate that we are, in fact, an integral part of Nature; we are Nature".

He was of course quite right. We are not above Nature or separate from Nature, we are subject to evolution in the same way as a toad or a fungus, a twig in the tree of life not intrinsically different, better or higher than any other. Darwin established that. True, we are the only species that has evolved to be able to alter even the physical properties of the earth's atmosphere. But like every other species we are still dependent for survival on the energy of the sun, and the integrity of global ecosystem

services. We speak of our control over nature, but that is an oxymoron; nature has never ceased for one moment to control us.

But in common parlance most of us, even scientists, continue to speak as if nature was something apart from us: we talk of the 'natural environment' in distinction from the 'built environment', of Scottish Natural Heritage as opposed to Historic Scotland, of the 'natural world', as the world apart from humanity. I shall do the same in the rest of this talk, but this use of nature and natural to mean only the non-human is a matter of subjective convenience, not of scientific reality.

The whole discussion of re-wilding, and of favouring native above alien species, depends upon by this definition of nature as beyond or before the human. Re-wilding and re-introduction, therefore, have more to do with history than science, if we define the wild as being in the state of nature, or what some term (following George Peterken, 1996) the 'original natural'. Re-wilders look to discover the condition of the environment before man acquired the power to alter it. They make a romantic and daring attempt to return to the Garden of Eden, using an assumed historical knowledge as a pass to re-enter it. They will use ecology once they get in, but they need history to tell them how to recognise the Garden, and to tell them what is native to the Garden and what is not.

The power of man to alter the environment came gradually and incompletely. In Scotland, the earliest traces of humanity yet found are those of hunter-gatherers at Cramond on the edge of Edinburgh, dated to about 10,000 years ago, within a millennium of the end of the last ice age. It used to be assumed that Mesolithic people were too sparsely distributed and ignorant to be able to alter their surroundings, but many archaeologists now think that they set fires big enough to make substantial woodland clearings, in order to attract grazing prey. Then came farmers: about 4000 years later there is evidence of Neolithic communities, the

first identified site being at Balbridie in Aberdeenshire. They practiced pastoralism. Then there followed the use of hoes for agriculture and of axes to clear woodland, and thereafter our ability to change the environment is not in question.

But even if we tried to recreate the environment of Mesolithic Scotland today, in one important respect it would not be authentic. The Scottish climate of the Mesolithic (and indeed the Neolithic) was variable, but generally more benign than it is today, warmer and less wet in summer, more like that of the south-west of modern France. No amount of search for the original-natural can recreate that situation now, though within a few decades when the effects of global warming kick in, it might become possible.

However, at the start of the Bronze Age about 4000 years ago, there was an abrupt change in the climatic systems, inaugurating the modern age of rising winds and rain. This had a dire natural effect on the existing vegetation and ecosystems of Scotland. So should we be looking to the Bronze Age as the model for an authentically re-wilded Scotland? From this point the formation accelerates of most of the raised and blanket bogs of Scotland, associated with the natural decline of forest. The latest findings of palaeoecology (Tipping, 2008) indicate that this was an entirely natural phenomenon, not in any sense anthropogenic, and you might argue that at this point nature in Scotland reaches its modern form.

Some would go further. James Fenton, whose work is not yet widely accepted or even discussed (being available mainly on-line) more contentiously argues that not only the bogs but also the open spaces of the heather moors are entirely natural, as in this new climatic regime the ground became incapable of supporting extensive tree cover: red deer would graze down regeneration, as it was not sufficiently protected in winter by snows as it was in Scandinavia (Fenton 2011) In his view, the open spaces of Scotland are not the anthropogenic wet desert of Fraser Darling (1956), created by overgrazing and human neglect, but the finest heritage of natural open space in Europe. It is threatened (he argues) by tree planting, not only of alien conifers, but also of Caledonian pine and other native woodland promoted by charities like Trees for Life, the Woodland Trust and the RSPB. Trees are, he would argue, inappropriate in most of the places where they are being encouraged because they threaten a natural, albeit Bronze Age and not Mesolithic, eco-system of open space.

This is the context of the species history of Scotland in the last 10,000 years. What about natives and aliens? The distinction between the two emerged only gradually, initiated by Victorian botanists in

the 1830s, by Darwin's mentor, John Stevens Henslow, and by the great father of British botanical geography, Hewett Cottrell Watson (Chew, 2011). As national and county floras began to be compiled, botanists wished to distinguish between a plant which was immemorially present and native in the wild, and one which had escaped from local gardens or had enjoyed an assisted passage in a bale of Australian wool or a consignment of American grain. The latter, the alien, was considered as less natural and authentic, and marked on their lists with an asterisk or a dagger, as it still is.

However, definitions of native and alien did not become set in stone until after the Second World War, in the context of the rise of genetics, and growing concern about the damage done by some releases of non-native species. In many cases, the question of what is native and what is alien is riddled with paradox and puzzle. (See Usher, 2000, Webb, 1985)

Broadly, for us, the native is the 'natural' inhabitant of a 'natural' Scotland. The last ice age left Scotland a tabula rasa, plants and animals from earlier interglacials having been removed by the extreme cold. Anything which came here since that time unaided by people is defined as natural. Anything that came through human agency is defined as an alien. It does not matter when they came, except that species that existed here in the interglacial before the last ice-age, but did not arrive unaided since the last one (like the Norway spruce) are classified as aliens. However, if a species has been made extinct through human agency at any point in time in the last 10,000 years, it is entitled to come back as a native, even if its return will need (as it often does) the most extensive and expensive human aid (and today also Government approval) to become re-established; capercaillie, beavers, sea eagles and red kites are the relevant cases in point in Scotland.

The alien, by contrast, is defined as a taxon with no earlier natural residency in Scotland, but which arrived with human assistance. Aliens are not considered natural in Scotland even if they arrived centuries ago, like rabbits, pheasants and sycamores, so are not normally afforded any legal protection as part of the natural heritage, though there are exceptions. For instance, the little owl is protected because the relevant mid-twentieth century legislation predates the highest modern anxiety about alien species, and in the interwar years scientists had spent a lot of effort demonstrating that it was harmless to game.

DISCUSSION

Unless you have wings or can float in the air like dust, there is certainly a large element of luck as to whether you are a native or not. Mammals were not

very lucky. Those which failed to make it to Britain before the final drowning of the land bridge over the North Sea about 8500 years ago, forever lost the opportunity to establish native status. So we have as native, red deer and roe deer but not fallow deer or sika deer, native otter and wild cat, but no native rats, native wood mice but no house mice and no native rabbits or brown hares. The house mouse came before the Romans (to Britain at least) the black rat came first with the Romans to England, with no proof of them in Scotland before the thirteenth century, and the brown rat (which has almost completely displaced the black) only in the eighteenth century. The rabbit came with the Normans to England, and specifically into Scotland probably with Normanised English monks. The oldest known colony is from the fourteenth century, on the Isle of May. The native beasts of post-ice-age Scotland initially included a whole tranche of splendid predators (brown bear, wolf, lynx) and large ungulates (auroch, wild cattle, wild boar and elk), as well as the beaver. The elk and the auroch perished before Roman times, the brown bear, the lynx, true wild cattle and the wild boar, probably in the in the middle ages, the beaver before 1600, and the wolf by 1700. In the general mayhem of the great game preserving age of the Victorians, the polecat also perished, while wild cat and pine marten were forced back to the remoter fastnesses of the Highlands.

Small rodents are especially interesting on the Scottish islands. The distinctive St Kilda house mouse is now extinct, barely surviving a year following the retreat of the human population to the mainland in 1930: it was akin to the house mouse of Norway, suggesting Viking involvement in its introduction (so it was an alien), and it had been there long enough to develop into a recognised subspecies about twice the size of a mainland house mouse (Love, 2009, Yalden 1999). The fact that it became extinct immediately on human withdrawal, seems proof of continuous human occupation of Hirta at least since Viking times, which some have occasionally questioned.

The other particularly interesting island rodent is the Orkney vole, a subspecies of the common vole of Europe and not related to the field vole that occupies the rest of the British Isles: recently it has been shown to have the closest relationship with Spanish common voles. As it is an animal found in Neolithic graves, and may be regarded as probably a totem animal or at least a pet, it is fair to assume it came over with the earliest settlers (Yalden 1999, also Yalden in O'Connor and Sykes, 2010). Like the St Kilda house mouse it is technically an alien species yet has developed into a native subspecies.

Squirrels are a special and fascinating case, worth lingering over. The red squirrel today is an

endangered native species that all but died out once before. In a process of protracted decline, it had evidently gone from Sutherland even before 1630, from Dumbarton, Moray, Ross and Cromarty by 1800, and from Angus, Aberdeenshire and Argyll before 1850, some apparently hanging on in Speyside. It is very unclear why the red squirrel declined like this. The conventional explanation of habitat loss seems most unlikely, as there were still plenty of woods left in the nineteenth century in all the counties listed. Disease is a more probable explanation, as we know that some form of squirrel plague devastated many English populations at this time. This indeed led to the introduction of grey squirrels to the London area by philanthropic Americans, who responded to the English wish not to be left without some sort of squirrel to amuse them.

The red squirrel might also have gone from Scotland at this point, had there not been deliberate reintroductions by landed gentlemen who also missed them, the most significant being those of the Duke of Buccleuch into his estate at Dalkeith from England in 1772 and of the Duke of Atholl into Dunkeld apparently from Scandinavia in 1790, followed by a natural reinvasion of the south-west from England, and further reintroductions to estates in the Highlands and elsewhere. What came in was probably not genetically identical with what had been lost. It is said that the descendents of the indigenous surviving red squirrels of Speyside can still be identified by a paler tail.

The reintroductions were only too successful. By 1900 red squirrels had reoccupied the Highlands and most of the Lowlands. They became universally regarded as a pest, and squirrel clubs were formed to keep the numbers down. The great naturalist James Ritchie in 1920 regarded the reintroduction of the red squirrel to have been an act of unconsidered folly, and the forester M. L. Anderson (1967) talked of the 'disastrous invasion' of the red squirrel, saying that 60,000 had been killed in 16 years by the Highland squirrel clubs, but without reducing the threat to Scottish forestry.

Meanwhile, 'some lunatic', in Professor Anderson's words, introduced a pair of grey squirrels to Loch Long about 1890, other owners introduced it into Fife, then into the Zoological Park in Edinburgh, and more recently they have also made their own way over the border from the burgeoning introduced populations in England. In most places where they advance, the red squirrel falls back, unable to compete, and threatened by a disease that the grey carries but from which it does not die.

Within two decades after the 1960s the red squirrel had swapped its old status as a reintroduced pest, for its present one of a charismatic native animal threatened by an alien. The Forestry Commission,

which had once supported the extirpation of the red squirrel, now supported clubs to kill the grey squirrel and discouraged the plantation of hardwoods in areas where doing so might encourage the grey squirrel and threaten the red. The ironies of history can be wonderful.

A relatively high percentage of land mammals in Britain are classified as aliens (21 out of 49 established species), but the overwhelming majority of British birds are classed as native. Wings meant that the flooding of the North Sea land bridge presented little problem for most of them.

On the other hand there are some very visible alien species among the birds—most notably pheasant, red-legged partridge, ruddy duck, mandarin duck, and Canada goose. Some populations of these originated from escapes or releases from private collections in England, spreading of their own accord across the border: others were introduced by noblemen for sport or ornament, the oldest, the pheasant, being first found in Scotland in the late sixteenth century.

A great fuss has been made about the American ruddy duck, which is heading for official extirpation in Britain, because of the threat of it flying off to Spain and interbreeding there with the native white-headed duck, and producing genetically confusing hybrids. By contrast, remarkably little fuss has ever been made about the ecological impact of the equally alien pheasant. A recent article in *British Birds* (Musgrove, 2013) indicated that some 30 million are released annually, and as 30-40% of their food for much of the year is insects, research would seem timely. I know of a population of dingy skippers, a scarce butterfly on Speyside, that disappeared after pheasant rearing pens were located in the vicinity.

Most native bird species breed in wild places that we readily identify as natural habitat, like dotterel on the mountain tops and gannets and puffins on offshore islands. Yet a number have such dependency on man-made places that their presence in Scotland is hard to imagine in the absence of people. But they are considered as natives too, sometimes described as commensals. Some are migrants like the swallow and the swift that come and go completely independent of man, but where would they nest if there were no buildings? Others may actually have hitched a lift with people, as they are reluctant migrants, but because they occupy adjacent continental Europe they are presumed to have crossed the water by themselves. We assume that the house sparrow came of its own accord, but it might have come as a pet of neolithic man, and the corn bunting does not normally move very far and is not likely to be able to exist without agriculture. On the other hand,

ringing returns do indicate that both species are actually capable of their own accord of flying the distance over the English Channel or the Minch, albeit infrequently. These particular commensal species probably all came in prehistory, but as late as the twentieth century we gained other species that are also entirely dependent on our activities. The collared dove completed an expansion north-west across Europe that had begun early in the century, by nesting in a farm garden in Moray in 1957, and has remained devoted to villages, gardens and farms ever since. The little ringed plover in southern Europe depended on bare areas of sand and gravel, expanded north taking advantage of the quarries of the construction industry, and arrived in Scotland in 1968 to nest on waste ground when the motorways were being built. It has since settled down to become a regular denizen of the gravel pits of Fife and elsewhere.

One set of native Scottish birds that are certainly not commensals but nevertheless arrived as breeding birds only recently, are most of the ducks. As late as 1800, only four species nested – mallard, teal, shelduck and eider, and possibly the common scoter. In the nineteenth century another six arrived – wigeon, pintail, tufted duck, pochard, goosander and red-breasted merganser. All of these continued to spread their range within Scotland in the twentieth century when they were joined by another three-- gadwall, goldeneye and garganey. (Forrester and Andrews, 2007). Why this should be is obscure, and seems to have had nothing to do with man, except that the goldeneye is almost entirely dependent on nest boxes. Perhaps it represents the last stage of a natural expansion of waterfowl out of Asia following the last ice age.

The mobility of birds is of course not normally shared by flowering plants. Forty-seven percent of the established taxa in the *New Atlas of British and Irish Flora* of 2002 are defined as aliens (Preston et al, 2002). Some were just a bit unlucky. The Norway spruce was naturally present in previous interglacials and is native to nearby Scandinavia, but this time never made it back west soon enough across the North Sea land bridge. Perhaps because its natural range in Europe is close and at a similar latitude to Scotland, when it was introduced for forestry it proved peculiarly hospitable to our native insects and birds. But the same does not apply to *Rhododendron ponticum*, another species present during a previous interglacial, but in this case introduced to ornamental parks and policies from more distant Spain. It has become a classic alien menace to natural eco-systems in Scotland, particularly invasive in the native oak-woods of the west. But it is worth remembering that not all invasive species are aliens; bracken is a native species, and if you go to Mull it is an open question whether you will be more alarmed by the recent

spread of *R. ponticum*, or the recent spread of bracken on moors where sheep grazing pressure has lightened. Certainly both tend to alter or obliterate what was there before.

Botanists are perhaps more sophisticated people than other folk, and have made a distinction between archaeophytes, introduced before around 1500, with the discovery of America and the first voyages to India, and neophytes, introduced later. The distinction separates out the plants that have come from other continents as a result of Empire and modern globalisation. The neophytes, far the most numerous as well as the more recent, include the unpopular Japanese knotweed, Himalayan balsam and giant hogweed, all escapes from cultivation after being introduced from Asia, and now considered pests. Nine of the top ten most rapidly increasing plant species in Britain are neophytes, eight of which were originally garden plants that got loose. The archaeophytes are a much smaller group, (5% of British flora are archaeophytes as compared to 42% which are neophytes). They are also much less successful: out of the 100 species showing the most rapid relative decline in Britain, 39 are archaeophytes. Eight out of ten of the most rapidly declining plant species in Britain are ancient weeds of arable fields that possibly came in with the Neolithic farmers, with resonant names like Good King Henry, Venus's looking glass and corn marigold (known in Gaelic as rot-the-corn). Interestingly, many are now protected, the Joint Nature Conservation Committee justifying protecting these aliens because they are at risk over much of their European range and of 'considerable historical and cultural interest'. (Cheffings and Farrell, 2005) This may be the first time that historical interest, as distinct from scientific interest, has become an explicit reason for over-ruling the native/alien divide in nature conservation.

I have not left myself much time to discuss other important groups, like insects, fungi or fish. Insects, or rather the most nimble flyers among them, like bumble bees, butterflies, dragonflies and hoverflies, have few alien species among them, though several are recent natural arrivals through anthropogenic global warming, like *Bombus hypnorum* among the bees and small red-eyed damselflies among the odonata. Few of these have yet reached Scotland, though our butterfly biodiversity has recently been enriched by long-established southern native butterflies like comma and large skipper that have invaded Scotland from England without other human help. Less mobile insects, like aphids and beetles, are more likely to provide alien species, as they come ashore in containers or on imported plants; unfortunate examples are the lupin aphid that arrived from America in 1981 and now reduces garden lupins to pulp in a matter of days, and the

harlequin ladybird, which arrived in Britain in 2004 and has also spread to Scotland. It is a threat to the 46 other, native, species of British ladybirds: let us hope it also eats the lupin aphids.

Fungi one might expect to have few aliens, as their spores should make them naturally mobile over great distances. Yet because the prevailing winds are from the south-west, those to the east that did not make it over the North Sea in Mesolithic times apparently find it hard to invade today. Andrew Taylor (2013) has recently shown how we have about 130 species of fungi of the genus *Cortinarius*; but this group is much better represented in Scandinavia, where there are 900 species, many of them associated with spruce forests. Because Norway spruce failed to make it over the North Sea, our *Cortinarius* fungi list is relatively short, and the west wind apparently stops them coming over to colonise our modern Sitka and Norway spruce forests which should be suitable for them.

Yet some of the biggest menaces to forests today are alien pathogens, fungus-like oomycetes, believed to have come from overseas in consignments of rooted horticultural plants, notably *Phytophthora ramorum* and other of the same genus, which in Europe infect rhododendron (including the invasive *R. ponticum*) and Japanese larch, and show signs of affecting even native bilberry and possibly heather as well. The danger of *Phytophthora austrocedrae* to the beautiful junipers of the Caledonian pinewood in Speyside has attracted remarkably little attention so far. Much better publicised is *Chalara fraxiniae*, ash dieback, a pathogen of Far Eastern origin which first appeared in Poland in 1991. In so far as it is associated with imported plants, it is an alien species; but the concentration of cases in Kent and East Anglia suggests that in this case it also arrived by air on a short sea crossing, either wind born or bird born, in which case should it strictly speaking also be classified as a native? These infections pose the biggest threat to British woodland ecosystems imaginable, and appear to be unstoppable.

I am not even going to attempt to deal with the species of the rivers and seas, as I have no time, except to mention that they too contain some really unwelcome invasive alien species, like the signal crayfish from America which is a threat to a range of biodiversity in our rivers, possibly including native pearl mussels, and Japanese wireweed, which out-competes native seaweeds. Some pests have come in association with aquaculture, others with shipping, either on the bottoms or in the bilge water.

SUMMARY

We are a species too, inescapably part of nature, just one of millions that have evolved. We have

categorised other species as either native or alien, and these categories are determined for some species by historic accident (whether or not they were able to cross by the land bridge), for others by their natural mobility (whether they could fly or float across the sea). Globalisation or trade, has been the main driver for adding alien species to our biodiversity, and though this has operated since Neolithic times (think of the Orkney vole), it began to accelerate after the discovery by Europeans of a direct route to Asia and the Americas soon before 1500, and has enormously increased in the past century. Alien species are defined as being brought into the country by human agency, but this is not to be confused with dependence on people: some native species have evolved towards almost total dependence on people (swallow or house sparrow), while many alien species, once they arrived, have little or no further contact or dependency on people – indeed it is their invasiveness in the natural world that causes most of the problem (signal crayfish in our waters) While most aliens are relatively new arrivals, others have been here for thousands of years, like the house mouse, the rabbit or the archaeophyte weeds of cultivation. Some of these have formed habitats around themselves, and there are serious ecological consequences when these are disturbed, as when one alien species (myxomatosis) devastated another (rabbits) and heathlands became scrubbed over.

Alien species are not to be unthinkingly equated with harmfulness, nor native species with being benign: some invasive species are native (like bracken and wood-pigeons) and many alien species live here doing no harm to anyone. But undeniably some alien species do have the capacity to become immensely destructive, and it is hard to tell which in advance. The deliberate release of non-native species into the wild is therefore wrong, as is the release of native species like hedgehogs onto islands where they have never occurred before and where they are locally aliens. Some species -- to use an old but valid word -- are pests. Dealing with species as pests is entirely reasonable, but what is needed is not dogma about native and aliens, but a sense of proportion and common sense.

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Translocation as a conservation tool: case studies from rare freshwater fishes in Scotland

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ABSTRACT

The use of translocation of animals to an ecosystem to which they are not native as a conservation strategy is controversial, but may be the only choice where *in situ* intervention is not possible. This strategy has been used to establish conservation refuge site populations for three important species of rare freshwater fishes in Scotland. Eleven translocations have been initiated over the last four decades in Scotland, five of these have resulted in the successful establishment of conservation refuges populations of Arctic charr, powan and vendace. The outcome of the remaining six is not yet certain. The approach taken has enabled the protection of, not only important species, but also of the considerable and discrete between-population diversity in phenotype and genotype that is found in these species.

INTRODUCTION

Although somewhat controversial (Müller & Eriksson, 2013), the use of translocation of plants and animals as a conservation strategy is increasing (Linklater et al., 2011). Translocation is normally considered appropriate in situations where a natural population is under threat and where *in situ* management intervention is not technically or economically possible. At its simplest, when used as a conservation tool, translocation usually involves the movement of individuals taken from a natural population to one or more suitable sites outside its current range to form a “conservation refuge” or “Ark” site (Maitland & Lyle, 2013). A flourishing scientific literature describing theoretical, practical and ethical studies of this technique, its

appropriateness, success rate and, the consequences of its use has been recently stimulated by consideration of potential conservation responses to climate change (Albrecht et al., 2012; Coleman et al., 2013; Chauvenet et al., 2013; Thrimawithana et al., 2013; Zeisset & Beebee, 2013). Of particular concern in this context, is the potential of plants and animals with poor powers of dispersal to adjust their range to track changes in the environment driven by climate change (Chauvenet et al., 2013).

Obligate freshwater fishes have poor powers of dispersal in the sense that they have very limited ability to move between (and sometimes within) unconnected water catchments (Adams & Maitland, 2001). Populations of obligate freshwater fishes of high conservation value have thus very little opportunity to disperse and avoid the negative effects of local environmental change in the habitats that they occupy naturally. This makes freshwater fishes particularly strong candidates for translocation intervention when conservation action is required.

In Scotland, a number of conservation translocations have been made to provide protection for freshwater fish species of high conservation value (Maitland & Lyle 1990). Arctic charr (*Salvelinus alpinus* (L.)), Powan (*Coregonus lavaretus* (L.)), vendace (*Coregonus albula* (L.)) and sparring (Smelt) (*Osmerus eperlanus* (L.)) have all been subject to this form of conservation action (see Maitland et al., 2009 on Sparring tranlocation). Here we review these actions for three of these species (Arctic charr, powan and vendace).

The Arctic charr in Scotland is a relatively common lake dwelling fish (Maitland, 2007) but there is significant between-population structuring in both phenotype (Adams et al., 2007) and genetics (Wilson et al., 2004) across the species. This has resulted from rapid evolutionary divergence of populations occupying different lochs in different catchments and more surprisingly between lochs within the same catchment (Alexander & Adams, 2000; Adams et al., 2007). The resulting effect is that different populations differ significantly in morphology, ecology, life-history characteristics and genetics. For this reason it is reasonable to argue that each population represents a significantly different biological entity that may require protection.

The distribution of the powan is considerably more restricted, occurring naturally in only two Scottish lochs, Lochs Lomond and Eck. There are no plausible records of this species having occurred naturally elsewhere in Scotland in the historical literature covering the last two centuries; although prior to this, there is no good reason to suggest that its distribution was not more widespread. As with Arctic charr, there is significant evidence to show that powan from these two natural populations differ significantly in morphology, parasite fauna, feeding ecology and life-history (Etheridge et al., 2012, and references therein). Restricted to only two sites at which the populations differ significantly, powan are highly vulnerable to any environmental change at either site. In 1982, a considerable threat to powan in Loch Lomond was identified. A non-native fish species, the ruffe (*Gymnocephalus cernuus* (L.)) was discovered there (Maitland et al., 1983); the population expanded rapidly to reach a very large population size over the following years (Adams & Maitland, 1998). This fish is known to prey upon fish eggs and was shown to be preying heavily upon the eggs of powan (Adams & Tippet, 1991).

The vendace, a close relative of the powan, had a restricted natural distribution in Scotland being restricted to only two glacial kettle lochs located near the town of Lochmaben in Dumfriesshire. The Mill Loch is small in area (13 ha) but relatively deep (16.8 m max) whereas the larger Castle Loch (78.2 ha) is shallow (5.5 m max) and thus these lochs could have supported only relatively small populations. Vendace were sampled from Mill Loch in 1966 by one of the authors (PSM) by which time the Castle Loch population was almost certainly extinct (Maitland, 1966). Further sampling showed that the Mill Loch population also became extinct sometime between 1966 and the mid-1970s (Maitland & Lyle, 2013). At this time the only other populations of vendace in the UK were in Bassenthwaite Lake and Derwent Water, two

interconnected lakes in the English Lake District (Maitland, 1966).

CONSERVATION TRANSLOCATIONS OF ARCTIC CHARR, POWAN AND VENDACE

There have been at least 11 concerted conservation translocations, (which have been undertaken under licence) of these three species in the last 40 years. Six of these are described in detail elsewhere and thus only a brief summary is presented here, more detail is provided on the remaining translocations.

Arctic charr

Megget and Talla Reservoirs

Loch Doon supports a population of Arctic charr which, by the 1980s, was at risk from acidification (Maitland et al. 1990). Between 1986 and 1990 a programme of translocation of adult fish and juveniles to Talla Reservoir and of unfed fry (hatched from eggs collected from 101 females) to the nearby Megget Reservoir both in the Scottish Borders (Table 1, Fig. 1) was conducted. In Talla, the charr are known to have spawned successfully within two years and in Megget, charr were recorded in gillnet sampling in 2010 (see Maitland & Lyle 2013 for more detail).

Vendace

Daer reservoir

Vendace sourced from Derwent Water were translocated to Daer Reservoir (Figure 2) in 1998 and again in 2005 and 2008 (Table 1; for more detail see Maitland & Lyle, 2013). The 1998 transfer was of 12,800 unfed fry and, in 2005 & 2008 an additional 25 adult individuals and 32,300 eggs were also translocated. Survey netting in 2003 and again in 2009 found no evidence of establishment success however it is likely that fish from the 2005 and 2008 translocations would not have been easily detected in the 2009 survey. Thus the success of this translocation remains uncertain (see Maitland and Lyle 2013).

Loch Skeen

Vendace sourced from Bassenthwaite Lake in the English Lake District were translocated as 17,500 unfed fry and 47,500 eyed eggs to Loch Skeen in the upper catchment of the River Annan in 1997 and 1999 (Table 1; Fig. 2). Subsequent survey work showed the establishment of a large population of vendace there (see more detail in Maitland & Lyle (2013) and references therein). Ironically the source population for this translocation, Bassenthwaite Lake, is now thought to have become extinct (Winfield et al., 2012) thus Loch Skeen may provide the only available extant conservation material for any future conservation measures for this population.

Loch Valley

Loch Valley lies in the Galloway Forest Park and was the site chosen for an early trial of Mill Loch vendace (egg) translocation in 1968 (Maitland, 2007). However, this failed - probably due to the severe acidification of the loch. Acidity is now much reduced (Marine Scotland Science pers. Comm.) and an introduction from the Derwent Water vendace population was carried out in 2011 (Lyle & Dodd, 2011). Some 70,000 eyed eggs nearing hatching were transferred to Loch Valley in March 2011 (Table 1; Fig. 2) and a survey to determine if this has been successful should be conducted within the next few years.

Powan
Loch Sloy and Carron Valley Reservoir

Between 1988 and 1990 both male and female powan were collected at spawning time (January) on known spawning grounds in Loch Lomond and eggs stripped from 22 ovulating females, fertilised with milt from mature males and incubated until hatching. Before the emerging fry had utilised the nutrition from their yolk-sac and thus begun exogenous feeding, ca 13,100 unfed fry were released to a refuge site at Carron Valley Reservoir and ca 12,200 to Loch Sloy. An additional 85 adult fish were also translocated to Loch Sloy. Multiple subsequent surveys to examine the status of these translocated populations have shown that they are well established and flourishing. The detail of these translocation efforts have been described elsewhere (see Maitland & Lyle, 2013)

Table 1. Conservation translocations of Arctic charr, vendace and powan in Scotland the source and destination sites, material transferred and establishment success, since 1985. Number of families is an indication of the number of full or half sibling groups translocated (except when marked * which indicates the number of groups comprising eggs from a single female) (a more detail in Maitland & Lyle, 2013).

Species	Year	Source	Destination	Life stage (N)	Number of families	Successful establishment?
Arctic charr	1986-1990 ^a	Loch Doon	Talla Reservoir	Adults (131) Juveniles (31)	unknown	Yes
Arctic charr	1986-1990 ^a	Loch Doon	Megget Reservoir	Alevins (18,300)	101*	Yes
Vendace	1998 ^a	Derwent Water	Daer reservoir	Unfed fry (12,800)	6*	Uncertain
	2005 & 2008 ^a			Adults (25) Eggs (32,300)	14*	
Vendace	1997 & 1999 ^a	Bassenthwaite Lake	Loch Skeen	Unfed fry (17,500) Eggs (47,500)	35*	Yes
Vendace	2011 ^a	Derwent Water	Loch Valley	Eggs (70,000)	33*	Unknown
Powan	1988-1990 ^a	Loch Lomond	Carron Valley Reservoir	Unfed fry (13,100)	22*	Yes
Powan	1988-1990 ^a	Loch Lomond	Loch Sloy	Unfed fry (12,200) Adults (85)	22*	Yes
				Eggs (10,200)	Unknown	
Powan	2009	Loch Sloy (Lomond origin powan)	Lochan Shira	Eggs (39,200)	9	Unknown
Powan	2010	Loch Lomond	Lochan Shira	Unfed fry (51,100)	41	Unknown
Powan	2009	Loch Sloy (Lomond origin powan)	Allt na Lairige	Eggs (6840)	46	Unknown
				Eggs (23,040)	41	
Powan	2010	Loch Lomond	Allt na Lairige	Unfed fry (41,800)	168	Unknown
Powan	2010	Loch Eck	Loch Tarsan	Unfed fry (115,300)	unknown	Unknown
Powan	2011	Loch Eck	Loch Tarsan	Unfed fry (9,000) Adults (150)		Unknown
Powan	2010	Loch Eck	Loch Glashan	Unfed fry (90,600)	168	Unknown
Powan	2011	Loch Eck	Loch Glashan	Unfed fry (9,000) Adults (136)		Unknown

Table 2. The search criteria use to find sites suitable for supporting a conservation refuge (Ark) site for powan from Lochs Lomond and Eck using the criteria of the IUCN (IUCN 1997) modified to include site characteristics meeting the ecological needs of a self-sustaining population for the species and for features of the site that would be likely to support long-term ecosystem and population security.

Search criteria	Evaluation	Rational
Ecosystem conservation importance	Ecosystem unmodified and/or of conservation value	Systems that have been highly modified for other reasons (such as reservoirs) are less likely to support important fish communities
Geographic location	Proximity to site of origin	
Physical site characteristics	Waterbody area and volume	Larger waterbody size will support a larger and thus more robust refuge population
	Altitude	Higher altitude – greater buffering from climate change
	Maximum and mean depth	Greater depth more deep water refuge
	Suitable spawning habitat	A reasonable proportion of the littoral zone with suitable spawning substrate
Loch Hydrology	Water level maximum, minimum and range during the spawning period	Reduced water level during the egg incubation period – greater risk to egg survival
Water chemistry	Overall nutrient loading	High nutrient loading unsuitable for powan
	pH	Low pH unsuitable for powan
Fish community	No populations of powan in a directly connected water	Risk of genetic introgression between diverged populations
	No populations of Arctic charr in a directly connected water	Risk of competition between these two species
Recreational fisheries	Active management for exploited species	Some recreational fishery management practices are likely to be unsuitable for powan
Security	Possible long-term changes to the catchment or water body that might be detrimental to an establishing powan population	

Lochs Tarsan & Glashan, Lochan Shira & Allt na Lairige

In 2007 as a result of potential additional risks to the established conservation refuge population of powan in Loch Sloy from proposals by Scottish and Southern Energy (SSE) to modify the hydro-power scheme there, plus consideration of potential risks to the Loch Eck powan population (which did not have a conservation refuge), a search began for possible suitable sites to create two more conservation refuge sites for powan from each of the Loch Lomond and Loch Eck populations. SSE offered seven hydro-electric reservoirs in the region for assessment as potential refuge sites. To

determine the suitability of sites from amongst these as long term host sites for powan, existing information was collated and evaluated in a desk study against criteria drawn from international guidelines for conservation translocations (IUCN, 1998; IUCN, 2012) These criteria specify site characteristics meeting the ecological needs of a self-sustaining population for the species and for features of the site that would be likely to support long-term ecosystem and population security. The search criteria and how they were used in practice are described further here (Table 2).

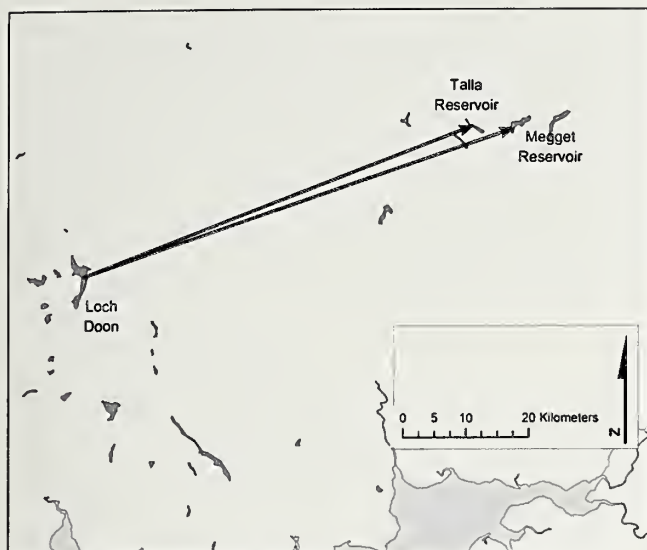


Fig. 1. A map of south-west Scotland, showing Arctic charr source population (Loch Doon) and conservation refuge sites (Talla and Megget Reservoirs).

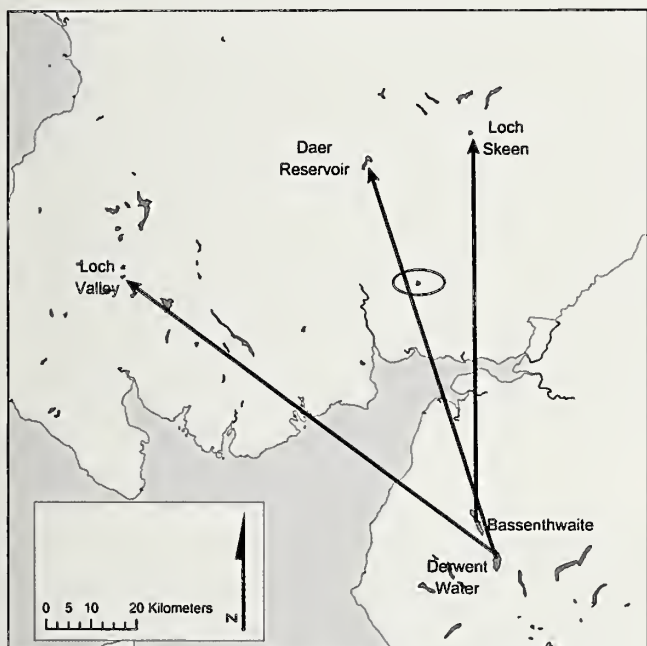


Fig. 2. A map of south-west Scotland and north-west England showing vendace source populations (Bassenthwaite Lake and Derwent Water) and conservation refuge sites (Loch Skeen, Loch Valley and Daer Reservoir). The location of the now extinct Castle and Mill Lochs vendace populations are highlighted by the ellipse.

SITE EVALUATION

Ecosystem conservation importance - IUCN Guidelines for Re-Introductions (IUCN, 1998; IUCN, 2012) indicate that any conservation translocation should not be carried out if there is the possibility of this resulting in significant damage to an ecosystem of high conservation value at the refuge site. In this case the reservoirs in question were established by impoundment, either of an existing loch, or to create a new loch where none existed previously, and were

therefore less likely to have a high conservation value, although this was still assessed.

Geographic location - IUCN guidelines (IUCN, 1998; IUCN, 2012) recommend that the introduction sites should, where possible, be located as close to the donor site as possible. Thus the relative proximities of the candidate reservoirs to Lochs Lomond and Eck were considered as a criteria for assessment of possible translocation sites.

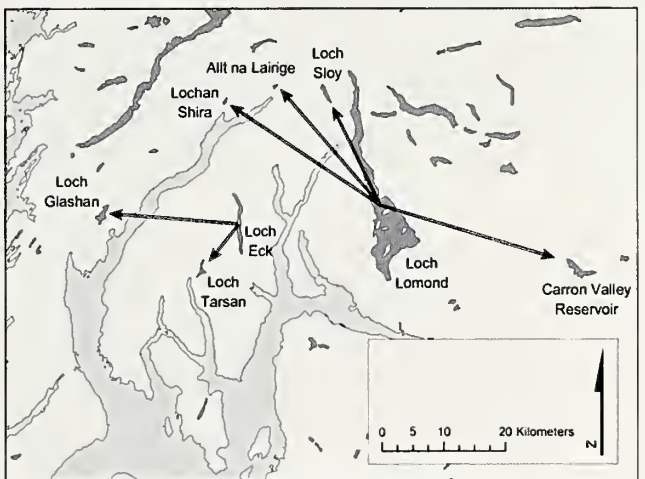


Fig. 3. A map of west-central Scotland showing powan source populations (Loch Lomond and Loch Eck) and the location of the conservation refuge sites (Carron Valley Reservoir, Loch Sloy, Lochan Shira, Allt na Lairige reservoir, Loch Tarsan and Loch Glashan).

Physical characteristics of sites - a number of specific site characteristics provide information to help evaluate the ability of the site to meet the habitat requirements of a self-sustaining powan population and its long term sustainability. The loch area and volume provide an assessment of the potential maximum powan population size that the site might support. Generally, larger sites have the potential to support a larger population size, which may be less affected by genetic drift, when compared with sites of a relatively smaller size. Powan require relatively cool water and, with the potential of some surface waters of Scottish lochs to exceed temperatures that may be lethal for powan (Maitland & Lyle, 2013), one habitat requirement is an available deep water refuge of significant size. Thus maximum depth, mean depth and the size of the deep water area of the putative refuge sites were regarded as important. Volume development (V_d) was used as a proxy for the size of the deep water refuge where $V_d = 3D_{mean}/D_{max}$ (Hakanson, 1981). A higher value of V_d denoting a greater proportion of deep water and therefore greater suitability for powan. In the absence of empirical data, the altitude of a site provides a measure of the probable temperature range of the water; higher altitudes indicating lower summer mean temperature. Altitude was also used as an indication

of the potential long term security of the site, with higher altitude buffering against the effects of future temperature rise resulting from climate change.

Hydrology - powan spawn over the littoral and sub-littoral submerged beaches with suitable substrates, (Maitland & Lyle, 2013), water level regimes during the spawning and egg incubation periods (December to April) are thus very important to breeding success. Historical maximum and minimum water levels and water drawdown levels during the spawning and incubation periods were available for all the reservoir sites. The temporal drawdown regime was of particular importance, as the potential for eggs that were spawned in shallow water and then during their incubation being exposed by a drop in water level, resulting in either freezing or desiccation, would result in high egg mortality.

Water chemistry - powan require oligo-meso trophic water conditions (Maitland & Lyle, 2013) . For some sites, long term water chemistry data were available from the Scottish Environment Protection Agency (SEPA). The status of pH, conductivity, alkalinity, nitrate and total phosphorus were of particular interest in determining whether water chemistry was likely to meet the needs of this species.

Fish community - information from literature, Fisheries Trusts, angling clubs and local contacts was collected to establish what was known of the sites's fish communities. This also included information relating to fish stocking practices and other fish introductions.

Field Evaluation - all seven sites were visited and surveyed to determine the fish community structure. Of particular importance was the potential presence of pike (*Esox Lucius* L.) perch (*Perca fluviatilis* L.) or ruffe, a large population of any of these has the potential to prevent successful establishment of a potential prey species. The presence of Arctic charr was regarded as equally undesirable, being a high conservation value species with which powan are likely to compete. The availability and extent of good quality spawning areas was also assessed. Powan require a mixture of substrates ranging from gravels and cobbles in water depths from one to seven metres and an absence of fine silts (which may inhibit oxygen diffusion across respiring, incubating eggs) (Maitland & Lyle, 2013). Substrate could be best assessed at low (usually summer) water levels or by using a bathyscope and underwater Remotely

Operated Vehicle (ROV) from either a boat or the shore as appropriate.

Determining the most suitable sites - the above data for the seven reservoirs were compiled and presented in detail to an expert panel comprising 11 individuals with a broad range of expertise in related fields and discussed. This process often referred to as the 'Delphi process' is particularly useful in situations where data partially limit decision making and it is an approach which has been used in the context of conservation management previously (MacMillan & Marshall, 2006). This process resulted in the identification of four reservoirs as possible refuge sites - Alt na Lairige and Lochan Shira for Loch Lomond powan and Loch Tarsan and Loch Glashan for Loch Eck powan.

CONCLUSION

Over the last 40 years, translocation to establish new, conservation refuge populations of rare lacustrine fishes has formed an important component part of the conservation effort of three species in Scotland. Two conservation refuge populations have been successfully established for Arctic charr from one threatened population. Three translocations of vendace from two endangered (one now extinct) populations in the English Lake District have resulted in the successful establishment of at least one conservation refuge population, the other two have not yet been confirmed. Greatest effort has focussed on powan, which has seen attempts to establish conservation refuge populations for two native populations under threat. Two of these have established successfully, the successful establishment of the remaining four have not yet been tested.

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Arctic charr (*Salvelinus alpinus*), fork length = 33 cm. Photo: Colin Adams.



Powan (*Coregonus lavaretus*), fork length = 29 cm. Photo: Colin Adams.



Vendace (*Coregonus albula*), fork length = 24.5 cm. Photo Alexander Lyle.

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Safe guarding pollinator populations in an intensive grassland landscape

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ABSTRACT

There is growing evidence that insect pollinators are declining globally and agricultural intensification has been identified as a major cause of this decline. To determine how pollinators utilise different habitats within an intensive grassland landscape, bumblebees and butterflies were monitored across a range of agricultural and semi-natural habitats using standardised transect walks. Few pollinators were recorded in intensively managed arable and grassland fields indicating that such habitats provided poor foraging resources. Hedgerows also yielded few pollinators reflecting the lack of pollen and nectar bearing plant species within hedgerows in this landscape. The highest density of pollinators, and richest pollinator assemblages, were recorded in open scrub, road verges and riparian buffer strips. This was most likely the result of such habitats supporting a diverse array of flowering plant species which in turn provided foraging opportunities for pollinators. These prime pollinator habitats should be managed to ensure that they maintain rich botanical assemblages and thus to ensure a continuous supply of nectar and pollen throughout the season.

INTRODUCTION

The post war intensification of agricultural practices and the associated loss of habitat diversity have adversely affected biodiversity across a range of taxa (Benton *et al.* 2002). Concern is growing that this loss of biodiversity will result in a degradation of the multitude of ecosystem services that nature provides (Flynn *et al.* 2009). There is mounting evidence that wild pollinators are in decline globally, with the intensification of farming practices and loss and degradation of semi-natural habitats being implicated in this decline (Vanbergen *et al.* 2013). With insect pollinators enhancing yields in approximately 70% of crops, the decline in pollinators poses a genuine threat to global food security (Klein *et al.* 2007). Furthermore, pollinators are also responsible for the pollination of many species of wild plants and thus have a critical role to play in preserving biodiversity. Furthermore within agricultural landscapes wild plants act as an important reservoir for pollinators

(Biesmeijer *et al.* 2006). This study aimed to determine which habitat components within an intensive grassland landscape were important for foraging pollinators.

MATERIALS AND METHODS

The Cessnock catchment, Ayrshire, Scotland (N55°32'50", W4°22'00") is dominated by productive ryegrass, *Lolium perenne* L., swards encompassing livestock grazing and/or cutting for silage. Land cover was mapped in GIS (Arc10) and 12 habitats that are either dominant in the catchment, or deemed important with respect to integrating biodiversity goals within intensive agricultural systems, were selected for survey. The selected habitats were Arable, Intensive Grassland, Rough Grassland, Open Scrub, Riparian Buffer Strips, Coniferous Woods, Coniferous Wood Edges, Deciduous Woods, Deciduous Wood Edges, Intact Hedges (hedges with no gaps over 2 m), Sparse Hedges (hedges with gaps over 4 m) and Road Verges. A total of 5 sites were surveyed for each of the 12 habitats thus yielding a total of 60 sampling sites. However, cattle gained access to one riparian buffer strip and this site was subsequently omitted from all analyses. Mosaic-level sampling with sampling points in multiple types of patches was therefore conducted (Bennett *et al.* 2006). Pollinators were monitored June-August (a total of four sampling periods) by standardised transect walks under conditions described as suitable by the Butterfly Monitoring Scheme Standards. Transects were 100 m long by 4 m wide with the exception of road verges where due to width limitations transects were 200 m long by 2 m wide. All butterflies, bumblebees and plants in flower that occurred in transects were identified to species level and quantified. Prior to analyses, all pollinators recorded at any one site were pooled over the four sampling periods and the resulting data log transformed to normalise. To investigate the impact of habitat on pollinator assemblages, analyses of variance were conducted on the following response variables: Number of Bumblebee Species, Abundance of Bumblebees, Number of Butterfly Species and Abundance of Butterflies.

RESULTS AND DISCUSSION

Highly significant effects of habitat were found for all measures of pollinator abundance and species richness (Fig. 1 and Table 1). Transects conducted in intensively managed agricultural habitats (i.e.

intensive grassland and arable land) indicated low utilisation of these habitats by pollinators. Few flower species were found in these habitats and it is likely that the lack of pollinators was a result of a lack of floral resources.

Table 1. Impact of habitat on butterfly and bumblebee species richness and abundance.

Response Variable	F-Value P-Value df (11, 47)	Location of difference
Butterfly species richness	F=3.57 P<0.001	Open Scrub> Intensive Grassland, Deciduous Woodland, Arable
Butterfly Abundance	F=3.92 P<0.001	Riparian Buffer Strip>Arable and Intensive Grassland
Bumblebee species richness	F=7.33 P<0.001	Open Scrub>Intensive Grassland, Coniferous & Deciduous Woodland, Coniferous Wood Edge, Arable Road Verge >Coniferous Wood Edge, Arable Riparian Buffer Strip>Arable
Bumblebee abundance	F=4.84 P<0.001	Road Verge>Deciduous & Coniferous Wood/Wood Edge, Arable, Rough & Intensive Grassland, Sparse & Intact Hedges Scrub> Deciduous & Coniferous Wood, Coniferous Wood Edge, Arable, Intensive Grassland, Sparse & Intact Hedges Riparian Buffer Strip> Coniferous Wood Edge, Arable, Intensive Grassland, Sparse Hedge

Few pollinators were recorded in hedges (both sparse hedges and intact hedges). Again these habitats within the study landscape had little floristic diversity. This indicates the importance of including plant species which bear nectar and pollen such as honeysuckle (*Lonicera periclymenum*), blackthorn (*Prunus spinosa*) and dog rose (*Rosa canina*) during any future hedgerow planting and regeneration (Jacobs *et al.* 2009).

Coniferous woodlands, deciduous woodlands, coniferous wood edges and to a lesser extent deciduous wood edges were also found to contain few pollinators and pollinator species. The pollinators considered in this survey (i.e. butterflies and bumblebees) are predominately sun loving and thus may have been deterred by the shaded conditions typically found in woodlands. Our survey methodology did not, however, effectively sample pollinators in the tree canopy. Trees such as sycamore (*Acer pseudoplatanus*), lime (*Tilia x europaea*) and bird cherry (*Prunus padus*) can provide important nectar sources and an assessment of the tree species within each woodland transect may assist in determining the

likelihood that pollinators were active in the canopy.

Few bumblebees were recorded in rough grassland and the number of bumblebees recorded in rough grassland did not significantly differ from numbers recorded in intensively managed grasslands. The number of butterflies, and butterfly species, recorded in rough grassland, on the other hand, tended to be greater than that of intensive grassland (although this difference was not statistically significant). Rough grasslands support a greater diversity of grass species which in turn provides food for butterflies whose caterpillars feed on grass species such as the small heath (*Coenonympha pamphilus*) and meadow brown (*Maniola jurtina*). Grassland butterfly populations are particularly sensitive to agricultural intensification and many species have declined significantly over the past 20 years (European Environment Agency 2013).

Open scrub, road verges and riparian buffer strips were the most important habitats for both bumble-

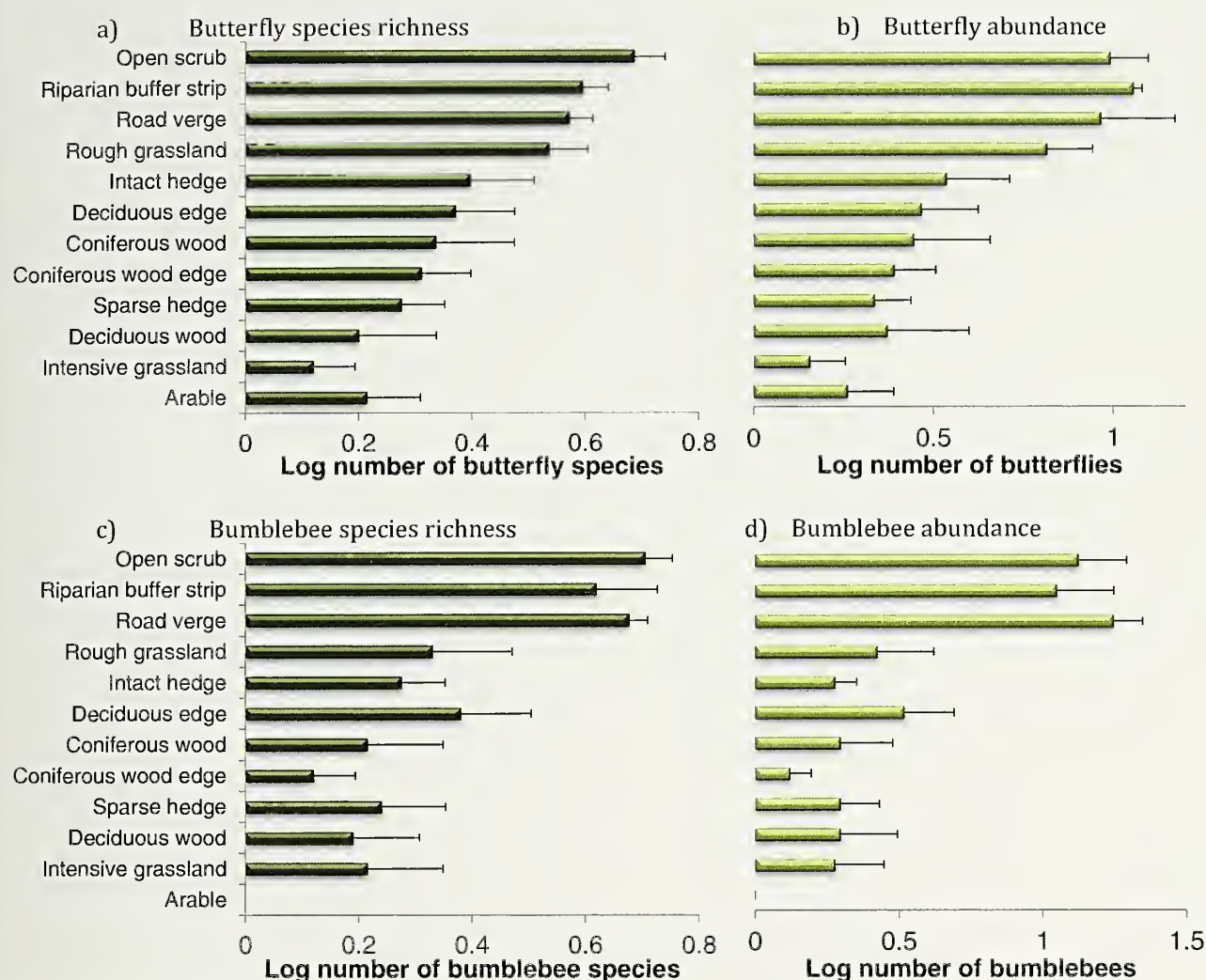


Fig.1. Impact of habitat on butterfly and bumblebee species richness and abundance indicating means (+standard error).

bees and butterflies supporting both taxonomically diverse assemblages and high densities of pollinators. These habitats had a high diversity of plant species which provided a continuous supply of nectar and pollen throughout the season. Such habitats are clearly important in providing foraging resources within intensive agricultural landscapes and this brings into question how these habitats should best be managed to obtain multiple benefits. For example, in the catchment area road verges were cut simultaneously in mid August when pollinators were still actively foraging and before flower seed formation. Delaying verge cutting till late September would not only prolong the availability of flowers for foraging pollinators but also allow flowers to set seed, thereby helping to maintain long term floristic diversity (Hambrey Consulting 2013).

Further analyses will be conducted to determine if habitat effects were solely due to differences in plant diversity. Observational evidence indicates that this may be partly, if not solely, the case. Pollinator presence was strongly linked to specific

plant species and numbers of pollinators within a specific site fluctuated depending on what plant species were in flower at the time of sampling. In general, raspberry (*Rubus idaeus*) and Russian comfrey (*Symphytum x uplandicum*) were important plant species in June, thistles (*Cirsium avense*, *Cirsium vulgare* and *Cirsium palustre*), woundworts (*Stachys sylvatica* and *Stachys palustris*) were important in July and knapweed (*Centaurea nigra*) and marsh woundwort (*Stachys palustris*) were important in August. Maintaining and enhancing plant diversity will increase the likelihood of providing a constant source of nectar and pollen throughout the pollinator season and thus of safeguarding pollinator populations in intensive agricultural landscapes.

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The Badger: victim or vermin? Bovine TB and badger baiting

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ABSTRACT

This is the text version of a talk given at the Glasgow Natural History Society's conference, 'Natives, Aliens and Reintroductions: how does ecology inform wildlife conservation in Scotland?' which took place in The University of Glasgow on the 22nd of June 2013. It is a brief assessment of the current attitudes to the badger (*Meles meles*) in England and Scotland and some comments on the statistics that are used to support those attitudes.

INTRODUCTION

Bovine TB (*Mycobacterium bovis*) is rarely out of the news just now and presents a real and present danger to the livelihoods of farmers in a number of areas in England and Wales. Badger baiting is a major problem across most of the U.K. with organised groups of individuals regularly targeting and digging badger setts or hunting badgers using dogs. In both cases there are difficulties addressing the problem due to a lack of accurate statistical analysis. In the case of bTB the true situation has been buried by a selective use of statistics for political purposes and with badger baiting the gathering and collation of statistics by official bodies has ceased altogether. In the former case we have too many statistics leading different groups to select only those that suit their argument and in the latter we have a complete lack of accurate statistics meaning that it is very difficult to gauge the size of the problem.

Bovine TB

Bovine TB is a serious problem in large parts of South West England and some areas of Wales. This paper will concentrate principally on the English situation and the government plans for rectifying it. The incidence of bTB has increased over the last two decades and its geographical range has expanded. It has been recognised for many years that there are reservoirs of infection within wildlife in some areas and that the badger (*Meles meles*) is one of those species. Whilst it is clear that in parts of England and Wales that some badgers suffer from bTB it has never been possible to establish how the infection is spread: from badgers to cattle or vice versa.

The numbers of cattle slaughtered as a consequence of bTB are frequently quoted by those seeking to emphasise the seriousness of the problem. There is no doubt that these numbers are high and that they cause huge problems both financially, emotionally and socially for the farmers involved. Businesses have been ruined and farmers and their families brought to despair by the loss of valuable beasts and sometimes whole herds. It is however, important to place the numbers slaughtered as a consequence of positive bTB tests in the context of annual cattle deaths as a whole.

Scotland is officially regarded as having bTB free status as the annual percentage of infected herds has not exceeded 0.1% for six consecutive years. This status has been achieved and is maintained, by a strict testing regime and movement controls. The following two quotations from a National Farmers' Union spokesman clearly support this. "Within the British Isles, Scotland is in a uniquely privileged position with low disease incidence and no wildlife component impacting on our disease picture." and "...the majority of TB breakdowns within Scotland are linked to animal movements from high risk regions and our best protection from this disease is care in how we source cattle and where possible selecting low risk animals."

This view is also held by the British Veterinary Association, whose then President, Nicky Paull, said in 2009, "The failure of the disease to take hold in Scotland can be linked to the strong legislative stance taken by the Scottish government on pre- and post-movement testing of animals coming into the country."

In 1997 the Krebs Report concluded that there was a lack of evidence about whether badger culling would help control the spread of bTB and proposed a series of trials. As a result the Randomised Badger Culling Trial (RBCT) was set up and ran between 1998 and 2006. This trial took place on thirty areas of approximately 100 square kilometres which historically, had a high incidence of bTB cases in cattle. Each of these ten areas was divided into sets of three, known as 'triplets'. One 'triplet' in each area was designated as 'Proactive', one as 'Reactive' and one as 'Survey'. In the 'Proactive triplets' as

many badgers as possible were eliminated throughout the 'triplet' by repeated culling. The intention was to keep badger numbers low. In the 'Reactive triplets' badgers were culled on and around farms, following a bTB outbreak, but not elsewhere. In the 'Survey triplets' no badgers were culled at all, regardless of bTB outbreaks but the land was surveyed for signs of badger activity to establish presence and give an idea of density.

Overall just under 11,000 badgers were culled during the trial. Numbers dropped to zero for 2001 because the trial was suspended during the foot and mouth outbreak in that year.

The percentage of culled badgers infected with bTB when summed across areas during the trial never exceeded 13%. It should be noted that in spite of claims to the contrary the vast majority of badgers within the area did not have bTB.

Following this extensive trial the panel concluded that "...badger culling can make no meaningful contribution to cattle TB control in Britain. Indeed, some policies under consideration are likely to make matters worse rather than better". They added "weaknesses in cattle testing regimes mean that cattle themselves contribute significantly to the persistence and spread of disease in all areas where TB occurs, and in some parts of Britain are likely to be the main source of infection..."

With regard to the way forward, the panel stated, "Scientific findings indicate that the rising incidence of disease can be reversed, and geographical spread contained, by the rigid application of cattle-based control measures alone." They went on to point out, "It is unfortunate that agricultural and veterinary leaders continue to believe, in spite of overwhelming scientific evidence to the contrary, that the main approach to cattle TB control must involve some form of badger population control." Finally, in a vain attempt to bring scientific rigour to the debate they said, "It is our hope that Defra will embrace new scientific findings, and communicate these to stakeholders in ways that encourage acceptance and participation."

The panel also added a warning, "Our findings confirm that badger culling can prompt the spatial spread of *M. bovis* infection, a phenomenon likely to undermine the utility of this approach as a disease control measure." Sadly, so far this has been ignored.

A frequently stated justification for the current cull is that the cost to taxpayers of bTB outbreaks is huge and increasing but the panel's report states, "...reductions in cattle TB incidence achieved by repeated badger culling were not sustained in the long term after culling ended and did not offset the

financial costs of culling." Further research undertaken by Professor John McInerney, University of Exeter concluded "Culling has never turned out to be worth it in strictly economic terms. It is a good deal for the farmers, but a bad deal for the taxpayers, in strict economic terms."

Following the report of the RBCT panel the government considered a number of options:

- 1) To continue with the current policy with no additional badger control measures;
- 2) To initiate a government led operation under The Animal Health Act 1981 to cull badgers;
- 3) To initiate a government led operation under The Animal Health Act 1981 to vaccinate badgers;
- 4) To issue licences to farmers/landowners under the Protection of Badgers Act 1992 to cull badgers.
- 5) To issue licences to farmers/landowners under The Protection of Badgers Act 1992 to vaccinate badgers;
- 6) To carry out a combination of options 4 and 5 issuing licences to farmers/landowners to either cull or vaccinate in response to applications.

At present option six is the one being taken forward in limited areas. A report by Godfray et al 2013 pointed out that, "The prospect of badger culling has resulted in bTB policy becoming one of the most contentious areas of policy-making that involves science in the UK." It seems unlikely that this situation will change in the near future.

The latest statistics show that whilst the numbers of cattle being slaughtered are rising the numbers of bTB tests being carried out have also risen. When the number of cattle slaughtered is taken as a percentage of the total number tested, a decrease is clearly noticeable.

A trial programme, culling free running badgers by shooting, is now (September 2013) underway in two areas of England. Unfortunately the trial is only concerned with the efficiency of the culling method and not with the effect of the culling on bTB. Because a raft of testing and movement restrictions have been introduced at the same time, any possible reductions in the number or spread of bTB cases cannot scientifically be attributed to either the culling or the movement controls.

Badger Baiting

Badger persecution has a long history in the British Isles and a number of laws have been passed in an attempt to reduce it.

The traditional method has been to locate a sett and dig into it during the day time when the badgers are most likely to be present. Terrier dogs are specially bred and trained to enter setts and corner badgers. Originally the hunters above would use the dogs

barking to pick the right spot to dig into the sett and remove the badger with a pair of metal tongs. Today technology, in the form of an electronic locator makes picking the right spot more of a science and less of an art. The terrier sent into the tunnel system wears a special collar that sends out a radio signal, which is picked up by his handler using a hand held receiver. The strength of the received signal indicates the spot on which to dig. Generally this activity reaches a peak in March and April when there are most likely to be cubs in the sett. The adult badgers are very loath to abandon cubs to be killed by a terrier and are most likely to put up a very fierce fight in their defence. Dogs that have fought a badger at this time of year are often considered to be the elite of the pack. Sadly they rarely live to enjoy this title for long. The injuries sustained by terriers fighting underground with badgers can be truly horrific and often fatal or life-threatening.

A second method of badger baiting has developed over the last few years and is becoming more popular. This involves hunting badgers above ground using sight-hounds, bull lurchers, specially bred for a combination of speed and strength. The badger is either flushed from the sett during the day or located on feeding grounds during the night, using a high-powered lamp and then hunted down by dogs. Although there are rumours of badgers being taken away alive for organised baiting in cities most of these unfortunate animals are simply torn apart at the scene and the remains are thrown into a hedgerow or stuffed into a sett entrance.

Intelligence that has been gathered indicates that there are a number of organised gangs based around the country who regularly indulge in badger baiting. These groups are known to, and often in regular contact with, one another and with others abroad, especially dog breeders. This contact is facilitated by use of social media on the internet as well as more sophisticated modes of contact. Activities are frequently recorded and stored on electronic retrieval systems and may be passed around fellow baiters or, on occasion, posted on internet sites. There are considerable sums of money available to these gangs that stem from their involvement in other forms of crime and some of their methods are extremely sophisticated. The levels of violence and intimidation against individuals who challenge the behaviour of these gangs as either complainants, investigators or witnesses, can be severe.

All police forces in the UK have Wildlife and Environmental Crime Officers who are specially trained in this complex area of work and in addition have the support of external experts and the animal welfare charities. Intelligence collection, collation and analysis are carried out by the National Wildlife Crime Unit which is based in Livingstone in

Scotland. Until the start of 2012 the unit maintained a central record of wildlife crimes reported to both the police and the non-statutory agencies. This role has now been discontinued, apparently due to financial constraints, which means that there is no longer any organisation that maintains the statistical database necessary to give an overarching view of wildlife crime in the UK. The third report of the 2012-13 session of the House of Commons Environmental Audit Committee said, "The NWCU should be directed and funded to develop a wildlife crime database to encompass all available information on incidents reported to the police and on prosecutions in the courts in the UK." This recommendation from parliament has been rejected by the government, throwing the burden of collecting and collating statistics on to charities. In the case of crimes against badgers in the UK, the only statistics available are those gathered by the UK Crime Prevention Lead, who is the Species Protection Officer for the charity Scottish Badgers. As the police are under no obligation to respond to requests for information, and that information is 'sanitised' in any case, this makes his work incredibly difficult. Badger persecution is a UK wildlife crime priority and it seems bizarre that, having recognised this, the government makes no attempt to gather the statistics necessary to establish the size of the problem and the effectiveness, or otherwise, of the various enforcement measures.

CONCLUSION

In the cases outlined above the badger has been categorised as either a verminous carrier of disease or a victim of sadistic cruelty. Deciding which of these two views is correct, or if the truth lies somewhere in-between, is a task that can only be helped by the collection and dissemination of high quality statistics.

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Using computer modelling to predict areas to search for chequered skipper butterflies *Carterocephalus palaemon* (Pallas, 1771) in Scotland

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The chequered skipper *Carterocephalus palaemon* (Pallas, 1771) is a native, UK Biodiversity Action Plan Priority butterfly species found in western Scotland.

The butterfly was well-known and reasonably widespread in the 19th and 20th centuries in the midlands of England, with scattered records as far as Devon, but gradually declined from the early 1900s. It remained common in the east midlands until the 1950s. It then underwent a rapid decline and became extinct in its last known English site in 1976.

In Scotland, the species was unknown until it was first found in the Lochaber area in 1939 (Thomson, 1980) and remained poorly recorded for the next 40 years. Surveys by the Scottish Wildlife Trust in the 1980s and Butterfly Conservation in the 1990s then established its general distribution. Records up to 2011 suggest that the Chequered Skipper is restricted to within a 30 mile radius of Fort William, from Loch Arkaig in the north to Loch Etive in the south, Ardrisaig in the west to Spean Bridge in the east.

The butterfly requires areas of lush purple moor-grass (the larval food plant) and this is often found growing near bog myrtle. The adult butterflies can be found in or near this habitat particularly where there are suitable nectar plants e.g. bugle, marsh thistle, bluebell and orchids, growing nearby in sunny, sheltered locations.

Adults are usually found in sunny glades or along the edges of damp woodland. In warm and sunny weather they are extremely active and fly with a swift, darting, almost moth-like manner that is difficult to follow as they 'skip' just above the vegetation.

The males guard their territories from favourite perches - often scrub, bracken or bog myrtle - flying out to inspect passing insects with the aim of

pursuing rival males and intercepting females. Females tend to be encountered in more open areas searching for suitable breeding sites. The butterfly could be mistaken for a small day-flying moth and is thus easily overlooked.

After mating, eggs are laid singly on purple moor grass in early June. The caterpillar spins the edges of the grass together to form a protective tube. Once it has eaten the leaf-blade down to the mid-rib, the caterpillar moves to a new leaf and starts again. In September the green caterpillar abandons its shelter and makes two semi-circular notches, one above the other, on opposite sides of the leaf-blade. It feeds on the leaf above this double-notch. The notches are thought to restrict the flow of nutrients from the leaf to the roots, creating a more nutritious meal.

The caterpillars hibernate from late October or early November to April within the spun leaves of their food plant. By spring they have changed to a fawn colour to match their surroundings and do not feed before pupating on the ground. The adult butterfly emerges around six weeks later.

Maintenance of flower-rich areas in sunny, sheltered locations is crucial for adults. Light deer browsing is important to prevent encroaching scrub shading out nectar plants. Light grazing, especially in autumn/winter, maintains flower-rich areas, but higher levels of grazing, particularly by sheep in the spring, can be damaging.

Chequered Skipper populations have declined where deer and livestock have been excluded from sites managed under woodland regeneration schemes due to loss of open space and nectar plants.

The adults and caterpillars have different requirements; at many sites their habitats occur as a mosaic. Females can move 1-2 km between nectar sources and breeding sites through open woodland and moorland. The precise habitat requirements are

not fully understood, although the following general principles apply:

The caterpillars spend most of their lives high-up on the food-plant, so light grazing can diminish food supplies, and also lead directly to mortality of caterpillars. However, breeding habitat usually occupies wetter areas which grazing animals generally avoid, unless stocking levels are high.

Its long-term survival, as with many other species, is more likely if sites are linked, enabling an exchange of adults between neighbouring colonies. The fragmentation of suitable habitat is damaging, making the surviving populations more isolated.

Many colonies now only survive under power-lines; chequered skipper and other butterflies benefit from the 7-10 year cyclical clearance of scrub beneath the wayleaves. Similar management can be deployed at under-grazed and un-grazed sites to retain or create open space along paths and rides and maintain glades. At larger sites this clearance should be staggered to produce open spaces at different stages of succession. Ideally rides and paths should run east-west to create a warm south-facing edge.

Butterfly Conservation's Allt Mhuic reserve is an area of grassland, moorland and native woodland between two large conifer plantations on the north side of Loch Arkaig. Butterfly Conservation run the reserve in conjunction with Forestry Commission Scotland. The reserve is intended to be used to build up knowledge of what kinds of management suit the chequered skipper (and other species), and which do not. The management of the reserve is being carefully monitored. Highland cattle have been used to do some of the light grazing required to keep the habitat suitable for the skippers, with mixed results, depending on time of year and number of cattle. Summer grazing was undertaken for eight years, but winter grazing over the last four years has so far given better results.

Butterfly Conservation use the reserve as a demonstration site and give talks to interested parties to describe the butterfly's ecology and requirements and how best to manage similar habitats in the area. They also have one to one meetings with land owners and managers on their own land to explain how to help the butterfly by undertaking appropriate management. This in turn is beneficial to the farmers, as they are more likely to be able to access grants if they are managing for the butterfly.

This can be done where the butterfly is known to occur, but do we really know the current distribution of the chequered skipper?

In 2011, Dr Tom Brereton, Head of Monitoring at Butterfly Conservation and Stuart Ball, Chief Analyst in the Data Services Team with JNCC, looked at what is believed to be the chequered skipper's requirements in terms of habitat, vegetation, topography, aspect, climate, amount of cloud and rainfall. They used a computer model which produced a remarkably good fit to the existing records, plus many potential new locations in which to search (Ball, 2012).

Taking the known distribution up to 2011, they then added the top 100 predicted 1km squares for the butterfly which the modelling suggested were best to search for chequered skippers, where they hadn't previously been recorded.

Most of these are within or close to the current known distribution area. However, there are also squares in the far north, in north-west Sutherland; in the Cowal Peninsula; and also one on Mull. Interestingly there were a couple of unsubstantiated reported sightings from Mull in the past.

The computer model suggests that the butterfly may have been under-recorded by 20% at a 10km level, and possibly by an astounding 400% at a 1km level. The next stage was to get groups of volunteers out to look at possible new sites to confirm the theory. In 2012, surveys were undertaken between mid-May and the end of June. Surveyors were asked to spend a minimum of an hour in the 1km square they were checking, or until they found a chequered skipper. They recorded the weather, time spent, other species seen, and other relevant information.

Despite the poor weather the survey raised a good deal of interest with over 50 volunteers signing up to take part. There were 49 survey visits to squares, (although this includes repeat visits by different surveyors to some squares) made to 36 different squares.

No chequered skippers were found in 21 of these squares, but the butterflies were found in 15 new predicted squares, and also in 15 additional new squares which had not been predicted in the top 100 (Prescott, 2012).

It was looked for, but not found on Mull, but encouragingly, there were some significant records elsewhere. The most southerly known Scottish sighting, in Glen Nant; a record from immediately to the east of Kinlochleven, which is around 7km to the east of the closest previous record; and a good population was found in seven 1km squares at the western end of Loch Arkaig, on the north-western edge of the butterfly's range (see Fig. 1).

Following the success in 2012, the survey was repeated in 2013. Visits were made to only 16 squares. Due to the very cold and late spring, the survey period was restricted to just over two weeks, and finished ten days earlier than 2012, which was probably the main reason for fewer squares being visited.

Efforts in 2013 concentrated mainly on two areas: Glen Etive and Loch Leven, and many of these records were made by a small number of recorders over a few days of good weather. Excluding repeat visits to the same squares Chequered Skipper was found in just six 'new' squares, although it had previously been seen in two of these in 2012. Of the remaining four, three were visited in 2012 and chequered skipper not found, with the fourth being a square that was not visited in 2012. Most excitingly the butterfly was also found in an additional 32 new squares that were not part of the top 100.

The butterfly was found in 17 adjacent 1km squares in Glen Etive. Many of which are new squares for the butterfly. Other new squares have been found in Glen Nevis, near Lochaline, Acharacle, Kinlochleven and Taynuilt. Really exciting is the record at the western end of Ardnamurchan – which is about 12 miles from the next closest record. The 2012 map (Fig. 1) clearly shows the westward extension of the Chequered Skipper's range along the Ardnamurchan peninsula, although this may be due to previous under-recording.

Overall (2012 and 2013), the species has been detected in 68 new squares (Fig.1). In addition to showing changes in known distribution, a detailed analysis of the survey data has been undertaken. (Butterfly Conservation, 2014). This information will help determine what conservation measures should be taken to help the Chequered Skipper in the future.

In addition to surveying for new sites, Butterfly Conservation has been working with Forestry Commission Scotland to monitor known sites for both Chequered Skipper and Pearl-bordered Fritillary, *Boloria euphrosyne*. In 2012 a total of 14 transects were walked for Chequered Skipper and 9 timed counts undertaken (Prescott, 2013), and even more in 2013, giving much-improved coverage for this important species. Forestry Commission Scotland are very keen for this to continue for at least three more years, and timed counts can be compared directly to FCS data.

A great deal of valuable data has been collected so far. Apart from recording Chequered Skipper, other priority species were recorded including Pearl-

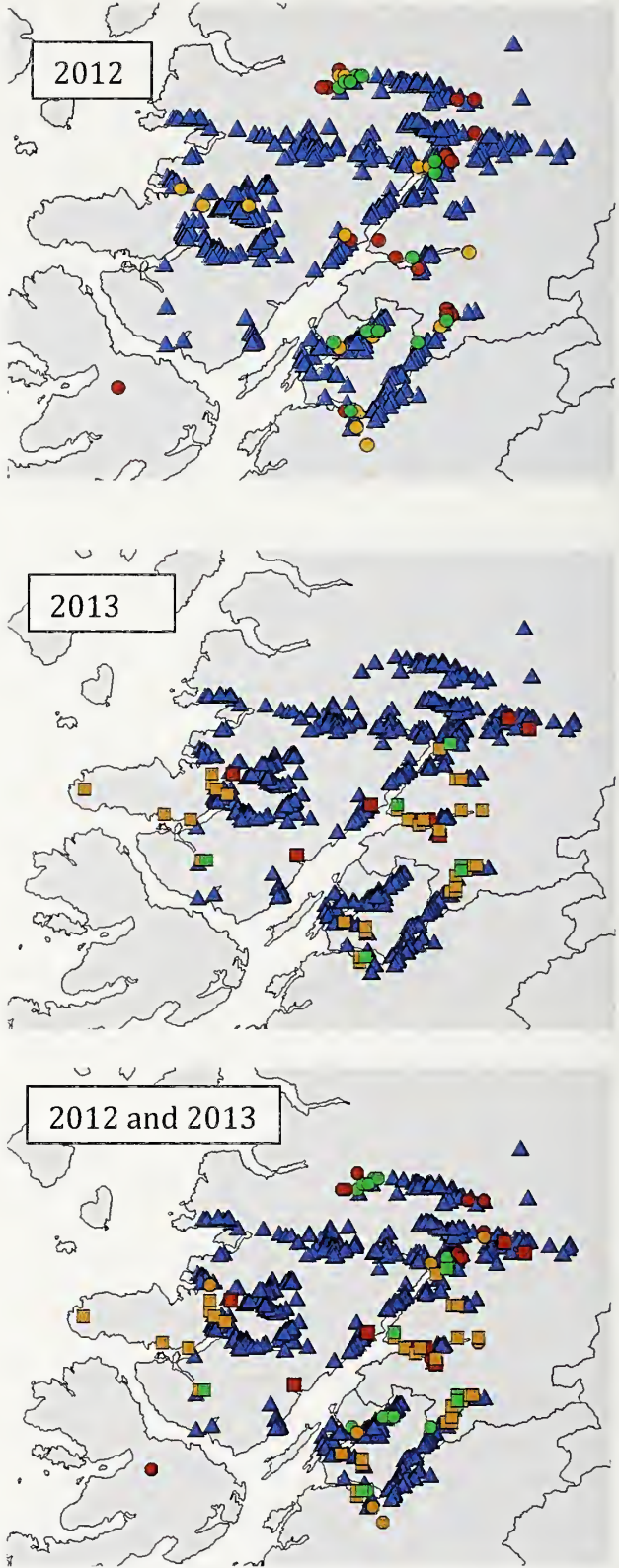


Fig. 1. Chequered skipper survey results for 2012, 2013 and 2012 and 2013 combined. Key: Blue Triangles = CS records 1980-2011. Green circles/squares = targeted 1km squares where CS was found. Red circles/squares = targeted 1km squares surveyed but CS was not found. Orange circles/squares = other new 1km squares where CS was recorded. NB: One Red Square in North-west Sutherland is not shown on the map.

bordered Fritillary, Narrow-bordered Bee Hawk-moth, *Hemaris tityus* and the Forester moth, *Adscita statice*. This methodology may well be suitable to try with other butterfly species. The most likely candidates are Pearl-bordered Fritillary and possibly Mountain Ringlet, *Erebia ephron*.

Such modelling techniques are a useful way of directing recorders to areas where target species are most likely to occur and shows that this is a good and efficient use of volunteers to undertake such work. The more work that is done on the ground, the more we can learn about this fascinating and scarce butterfly.

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Grass Snakes (*Natrix natrix*) in Scotland

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ABSTRACT

It is generally believed that grass snakes (*Natrix natrix*) do not occur in the wild in Scotland. However, recent confirmed records of grass snakes in Dumfries & Galloway encouraged a re-evaluation of existing data of the species in Scotland. The results demonstrate that the grass snake is present in Scotland, and provide a preliminary Scottish distribution for the species, with the known core range apparently being within Dumfries & Galloway and the Scottish Borders. Data also suggests that the grass snake may have been present in Scotland for some time, and is not a new arrival as a result of recent climate change or movements of agricultural material during the 2007 foot and mouth outbreak. The work has also proven a useful case study for biological recording, identifying a number of common sources of error even for a distinctive large vertebrate with relatively few records. Further research is required to clarify the status – both historical and current – of the grass snake, Scotland's rarest native reptile.

INTRODUCTION

It is generally believed that grass snakes (*Natrix natrix*) do not occur in the wild in Scotland, although they are sparsely distributed in both northern Cumbria and Northumberland (Beebee 2013; Inns 2009; Arnold, 1995; Arnold, 1983). While there are a number of records in Scotland, grass snakes were popular pets during the 20th Century, and records from the Central Belt have been attributed to captive escapees (Arnold, 1995).

However, on 10th May 2010 while undertaking great crested newt (*Triturus cristatus*) surveys for Caledonian Conservation Ltd on behalf of Amphibian and Reptile Conservation Trust (ARC) as part of a predictive habitat modelling project supported by Scottish Natural Heritage (SNH), Chris Cathrine recorded a grass snake in Dumfries & Galloway. The grass snake was flushed during newt egg searches, and Chris had excellent views of the distinctive pale neck collar as it swam into the pond, confirming the identification. The pond in which the grass snake was recorded was far from any population centres, and located at the border of

semi-natural mixed woodland and agricultural land, meaning it cannot be readily explained as an escaped pet, and is likely to be wild or feral. It is interesting to note that grass snakes had previously been reported where Chris Cathrine made his record in 2010, but had been dismissed out of hand without further investigation as they were not believed to be present in Scotland.

This find encouraged Caledonian Conservation Ltd to research other grass snake records in Scotland in partnership with Clyde Amphibian & Reptile Group (CARG), and an outline of results are provided here. As well as reconsidering the status of the grass snake in Scotland, this research also provides a useful case study of biological recording.

METHODS

Analysis of records

Original grass snake record data were gathered from as many sources as possible, including the National Biodiversity Network (NBN), Scottish Natural Heritage (SNH), Amphibian & Reptile Conservation Trust (ARC) and other charities, Biological Records Centre (BRC – including Arnold's 1995 atlas data), local records centres, local authorities, Amphibian & Reptile Groups and individuals. In addition, an appeal for additional records was made through media, with a dedicated Scottish Grass Snake recording scheme website being launched as part of the Record Pool online recording system (www.scottishgrasssnakes.org). Record Pool (www.recordpool.org.uk) is a joint project between Amphibian & Reptile Groups of the UK (ARG UK) and ARC, with the development of the Scottish Grass Snake recording page financed by Caledonian Conservation Ltd.

These data were then plotted in ArcGIS 10 (Fig. 1), and thoroughly verified. Verification involved checking grid references, notes, descriptions, habitat, context (with other Scottish and English grass snake records), local knowledge and provenance/recorder. In some cases recording schemes or original recorders were contacted for further information.

In total, 96 records of grass snake in Scotland have been collated, of which 32 were collected from the National Biodiversity Network (NBN) database. The process of thorough verification highlighted a number of categories of common data errors (Table 1). It was possible to address all sources of record error during this study, with the exception of race, which would require clear photographs and/or DNA analysis to determine.

Revised Distribution

After verification, four records can be confirmed as grass snakes in a wild environment – three from Dumfries & Galloway and one from the Scottish Borders (Fig. 2). These records range in date between 1920 and 2010, although three were recorded between 2009 and 2010. This is not necessarily an indication of recent colonisation however, but more likely reflects the difficulties in confidently verifying older records. None of these confirmed records are included in the NBN dataset.

A further eight remain as possible naturalised records that cannot be immediately explained as erroneous or escapes, and range in date from 1960 to 2004 (Fig. 2). Five of the possible records are from Dumfries & Galloway, and are from less experienced but reliable sources, from appropriate habitat and relatively near confirmed records.

A possible record from Loch Lomond is from a reliable source, but may relate to an introduced population as 200 grass snakes were released here at an unknown date in the late 20th Century.

Two independent records from Aberdeenshire in themselves seem unlikely, but in context become interesting as both are from the same catchment.

These possible records warrant further investigation, while surveys of Dumfries & Galloway will help determine the extent of this population.

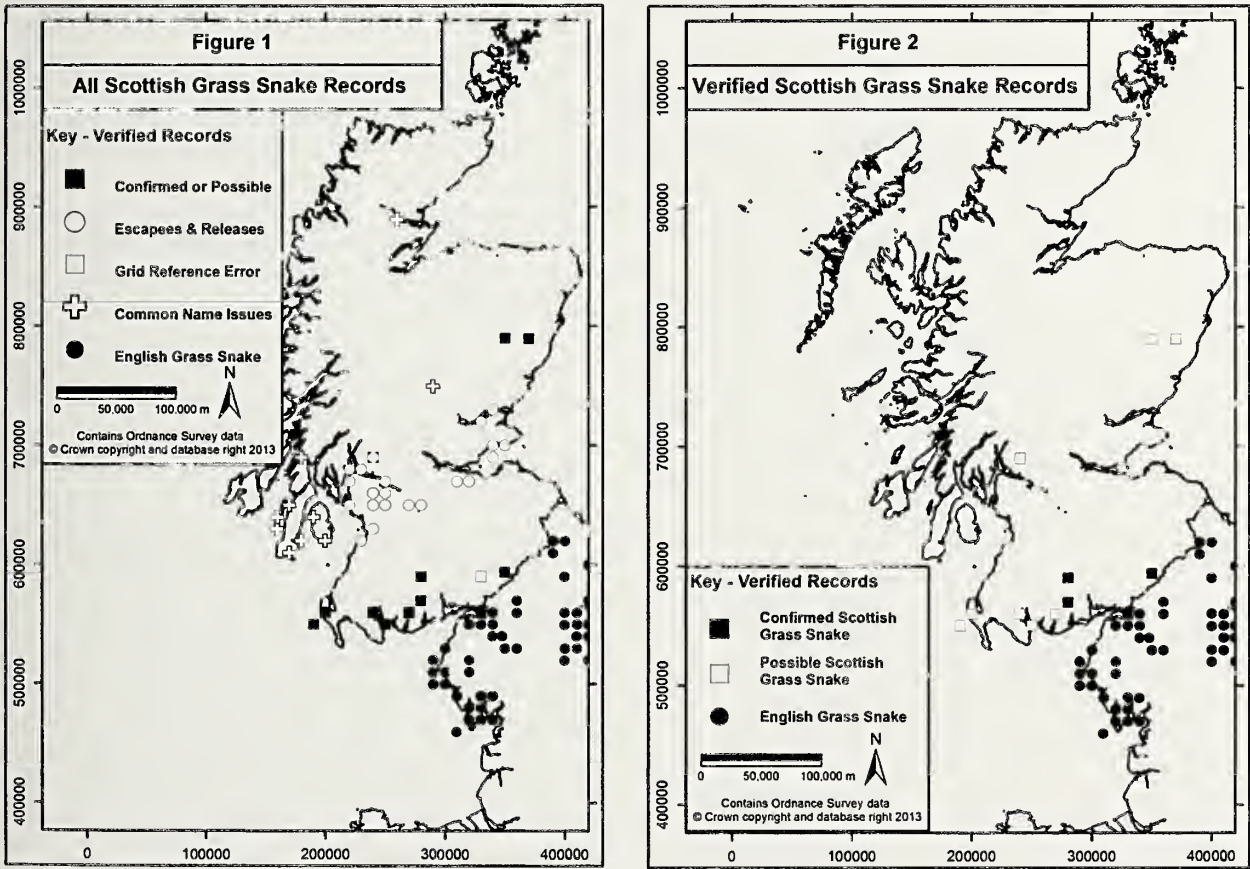


Fig. 1. All Scottish grass snake records and **Fig. 2.** Verified Scottish grass snake records.

Data Error	Description
Escapees	Grass snakes were popular pets during much of the 20 th Century, and there is a possibility that records from before the 1980s relate to escaped pets. Most of these records are from unsuitable habitat (e.g. urban amenity grassland areas). The possibility of escaped pets in populated areas meant that records from such locations during much of the 20 th Century could not be confirmed as wild grass snakes, and so were disregarded.
Releases	During the data search and verification process, this study found that 200 baby grass snakes were deliberately released into Loch Lomond during the late 20 th Century. However, it was not possible to confirm the date of release, and therefore any records from Loch Lomond could not be confirmed as wild grass snakes. As habitat is suitable for the species, there is a possibility that grass snakes may have been present in the wild prior to the release, but this cannot be confirmed.
Grid reference errors	Data entry errors are always a possibility, such as incorrect grid references. The most common error found lies with the unique two letter 100km National Grid square codes. Careful examination of notes and location names often reveals these errors. For example, the fairly well known Langholm population, which can be found in Arnold's 1995 atlas and on NBN, actually refers to a record from Windemere, where 'NY' was entered instead of 'SD', as revealed by the location name data.
Misidentification	A number of records were disregarded where the recorder was inexperienced or known to be unreliable.
Races	12 subspecies of grass snake have been described, although the true number is now widely accepted to be four (Arnold and Ovenden, 2002; Thorpe, 1984). Only one of the four subspecies is known to be native to the UK (<i>Natrix natrix helvetica</i>). Up to 15 distinct races of grass snakes are also thought to occur in Europe. Escaped pets have resulted in non-native races becoming established in the UK. For example, a population of grass snakes of Romanian origin have become established in Yorkshire and North East England (Nash, 2011). It was not possible to control for race in this study.
Common names	The common name 'grass snake' refers to the adder (<i>Vipera berus</i>) in Argyll & Bute, and to the slow worm (<i>Anguis fragilis</i>) in much of Scotland – particularly north of the Central Belt. However, previous recording projects have simply requested records of 'grass snakes' and so some people in Scotland will have submitted records of what they term 'grass snakes' quite genuinely. However, unknown to the organisation receiving these data these records refer to a different species. Some records clearly indicated alternative species based on habitat, description, notes and confirmation from recorders, and so were disregarded.

Table 1. Common record errors encountered during verification of Scottish grass snake records.

DISCUSSION

This study has confirmed that grass snakes are present in the wild in Scotland, with the core range apparently in Dumfries & Galloway and the Scottish Borders (Fig. 2). Given grass snakes are known to occur in Cumbria and Northumberland reaching the border between England and Scotland, this find does not seem surprising. This also appears to offer a more realistic and refined northern edge to the distribution of this species in the UK when compared with the straight line found at the border between these countries in recently published distribution maps (Beebee, 2013; Inns, 2009). Although it is not possible to determine if they are a recent arrival or have been present far longer, records are beginning to suggest grass snakes may have been present as naturalised populations for some time. For example, the lone confirmed record from the Scottish Borders actually refers to several

grass snake sightings at the same location between 1942 and 1945, and a possible record from the Rhinns of Galloway is from 1966. These older records are in remote locations unlikely to be associated with escaped pets, suggesting persistent populations have existed in Scotland for some time, and that grass snakes are not as recent an arrival as some potential explanations of new records would suggest (for example having been introduced with agricultural movements during the foot and mouth outbreak in 2007, or a new colonisation as a result of climate change).

A common reason cited for grass snakes not occurring in Scotland is that the climate is too cold to support the development of eggs, and that this is why the three widespread native reptiles in the country are all viviparous (Buckley and Cole, 2004). However, it should be noted that there is an

established introduced population of sand lizards (*Lacerta agilis*) in the Western Isles – an egg laying species (Beebee, 2013; Inns, 2009; Bowler and Hunter, 2007; Buckley and Cole, 2004). Grass snakes occur at higher latitudes in Scandinavia, where they are known from 58°12'N in Sweden, which is further north than the Aberdeenshire records (Löwenborg *et al.* 2010). Elsewhere the northern extent of the range of this species has been found to be at least 64°24'N, which is more northerly than the limit of mainland Scotland (Löwenborg *et al.* 2010). Grass snakes become an increasingly synanthropic species further north in their range, relying on anthropogenic features such as compost heaps and manure piles for egg laying sites (Hagman *et al.* 2012; Löwenborg *et al.* 2010). Although this study cannot confirm whether grass snakes are presently breeding in Scotland, it is interesting to note that all confirmed records and most possible records are in or near areas offering semi-natural woodland, freshwater habitats and agricultural land that may provide manure piles and compost heaps for egg laying.

There is no inherent biological or ecological reason that grass snakes would not occur naturally in Scotland. Post-glacial colonisation of the UK by some animals involved multiple events following different routes, or successional waves with different races persisting in the north after they had been replaced in the south (Searle *et al.* 2009; Pierny *et al.* 2005). The habitat and climate has also differed historically, allowing animals to establish populations throughout the country which have subsequently become isolated as conditions changed – for example great crested newts in the Inverness area have recently been found to represent a native population which has become isolated (Jehle *et al.* 2013). These possibilities should not be dismissed when investigating grass snake distribution in Scotland, as the species may potentially have colonised the country during a period with more favourable climatic conditions. However, if grass snakes are a recent arrival to Scotland, it is possible that topography and habitat may prevent the Dumfries & Galloway population from expanding north.

Further research is required to clarify the range and origins of Scottish grass snakes. In particular, photographs and/or DNA studies may help address the race question, while targeted surveys may determine whether grass snakes are breeding in the wild in Scotland. Encouraging further recording amongst experienced biological recorders and the wider public will also help provide a clearer picture of the distribution and status of this species in Scotland.

The study has also highlighted that record errors go unnoticed and can become part of widely referenced datasets such as NBN and atlases (e.g.

Arnold's 1995 atlas of amphibians and reptiles) even in relatively small datasets. It has also shown that common names can be a confusing issue even for a charismatic and easily identified vertebrate such as the grass snake, and so the importance of using scientific names when recording cannot be stressed enough. It is essential that records are thoroughly verified, particularly in the case of datasets that are often used to inform the decisions of ecological consultants and Planning Authorities.

Further work is clearly needed to clarify the status – both historical and current – of what is Scotland's rarest native reptile. It is hoped that surveys in the Scottish Borders and Dumfries & Galloway will be undertaken in 2014 to gain a better understanding of the current Scottish range of the grass snake.

ACKNOWLEDGEMENTS

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The Clyde Valley Wader Initiative: How applied ecology is informing the conservation of waders in South Lanarkshire

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ABSTRACT

Most species of grassland breeding wading birds ('breeding waders') have suffered dramatic declines in Scotland over the past 30 years and are now a priority for the work of the RSPB. The Upper Clyde Valley (including the Duneaton, Elvan, Daer and Medwin Waters and the River Clyde) continues to hold regionally, and for some species nationally, important populations of breeding lapwing, oystercatcher, curlew, snipe and redshank. The Clyde Valley Wader Initiative was instigated in 2008 with the aim of maintaining and increasing these populations through targeting funding and advice to landowners to encourage them to undertake 'wader friendly' farming practices, which are informed by the latest research into wader ecology.

INTRODUCTION

Breeding waders form an important part of the natural heritage of our farmland and uplands and the evocative calls and flight displays of species such as lapwings and curlews are often cited by authors and poets as capturing the spirit of the countryside. Whilst there are separate trends for different species, overall the populations of breeding waders have declined significantly since the 1990's (see Table 1).

Largely due to these population declines, lapwings are included on the 'red-list' of high conservation concern and curlews, oystercatchers, redshanks and snipe are included on the 'amber-list' of medium conservation concern in the assessment of the status of birds in the United Kingdom (Eaton et al. 2009). Curlews, lapwings, redshanks and snipe have been identified as a priority for the RSPB's work in the UK.

Table 1. Trend of breeding waders in the UK (Risely et al. 2012).

Breeding waders	Population trend (1995 – 2011)
Curlew	-45%
Lapwing	-41%
Oystercatcher	-16%
Redshank	-42%
Snipe	+8*

*This masks a significant post-war decline (Smart et al. 2008).

These population declines triggered a significant amount of research into breeding waders and this applied ecology has given us an understanding of both the needs of this group of birds and the likely drivers of their decline (Sheldon et al. 2004).

The grassland breeding waders that the project focuses on, namely curlews, lapwings, oystercatchers, redshanks and snipe all favour slightly different habitats for foraging and nesting. Lapwings and redshanks generally favour shorter swards, with few or scattered tussocks, whilst curlews and snipe prefer longer swards, with denser tussocks (Youngs, 2005). Collectively, however they tend to be associated with less intensively managed farmland, with high water levels; a degree of cover – often in the form of soft rush *Juncus effusus* and an open landscape, away from forestry or hedgerows (Stillman et al. 2006)

The primary cause of the decline in breeding waders is thought to be habitat change and degradation, including the drainage of wetland, the conversion of arable farmland from spring to autumn cropping and the planting of conifer forests on marginal farmland has fragmented open landscapes which waders prefer (Wilson et al. 2004, Eglington et al. 2008). There is increasing evidence showing predation is a proximate driver of declines, in the uplands, as a result of declines in predator control, principally undertaken by game-keepers, and due to afforestation increasing the densities of predators of open landscapes (Douglas et al. 2013, Smart et al. 2013). Climate change, and in particular increased rainfall at certain times of year, may also be putting pressure on wader populations (Hulme, 2005).

Previous Studies in the Clyde Valley

There have been several breeding wader surveys carried out in the Clyde Valley area (encompassing, for the purpose of the project and this article, parts of the floodplains and surroundings of the

Duneaton, Elvan, Medwin and Daer Waters and River Clyde in South Lanarkshire) in the last 25 years, starting with extensive surveys by local volunteer Alan Wood in the late 1980's. There were then a handful of sites surveyed in 1992/93 as part of a nationwide survey to assess key breeding wader sites on Scottish in-bye farmland (O'Brien and Bainbridge, 2001). Some of these sites were then resurveyed in 2005 as part of a research project to see how breeding waders responded to sites under agri-environment management compared to sites without agri-environment management (O'Brien and Wilson, 2011). Finally, some farms in the area were surveyed as part of RSPB Lapwing Recovery Project in 2007/08, which assessed whether additional management for waders, on top of agri-environment prescriptions, could result in increased breeding success.

This background survey information, coupled with the anecdotal evidence that the Clyde Valley still had good numbers of breeding waders, lead to RSPB Scotland prioritising the area for work and embarking on the Clyde Valley Wader Initiative; a landscape-scale project with the aim of addressing the declines in breeding waders. It seems to be the case that when managing for specific species of conservation concern, working at a landscape-scale is more effective (Dallimer, 2010). This is likely to be particularly pronounced for breeding waders, which favour open landscapes, with minimal field boundaries (Stillman et al. 2006).

Funding

A further driver of the Clyde Valley Wader Initiative was the provision of funding for 'wader-friendly' management through the Scotland Rural Development Programme (SRDP), specifically the 'Farmland Waders' package of the competitive Rural Priorities scheme, and to a lesser extent, some options within the uncompetitive Land Managers Options' scheme. SRDP is administered by the Scottish Government and are made up of European and domestic funding. RDC differs from the other funds in SRDP in that it is a competitive process, whereby rural businesses prepare bids for funding, with the aim of targeting money to where it will achieve most benefits. The Scottish Agricultural College (now SAC Consulting) acted as agents for many farmers in the Clyde Valley and was responsible for drawing up the bids for RDC funding. RSPB Scotland was concerned that without additional advice, the lack of information and resources available to those developing the bids or administering the funds might have meant that funding went to areas where no waders were ever likely to present, because for example, they were too close to forestry or on unsuitable fields for breeding waders. Due to this concern, RSPB Scotland approached SAC with the aim of advising

them on funding bids for wader packages and supporting appropriate bids to SRDP.

Assessing Farms

SAC acted as agents for many of the farms in the Clyde Valley. Partly because it fitted with existing management practices and partly because of the connection made between SAC and RSPB Scotland, many of these farms submitted bids for SRDP funding based on management for breeding waders. By far the greatest form of management proposed involved minimising grazing pressure on fields entered into the bid to avoid the risk of trampling of nests, as this tended to tie-in with existing farm practices. Staff from RSPB Scotland visited all the farms to discuss the management with the farmers and assess and advise on their suitability for breeding waders. Factors when assessing the suitability of the fields were:

- Extent of rush cover (approximately 20% - 30% was positive, over 40% negative)
- Areas of surface water or mud (positive)
- Presence of waders (positive)
- Proximity of hedgerows or forestry (negative) and wider landscape character

One challenging issue that arose was that new hedgerows were proposed in many of the bids to gain additional points under the RDC scoring programme. Sometimes the hedgerows were to cross areas that were proposed to be managed for breeding waders, which would be likely to reduce their value for this group of birds. In this instance RSPB Scotland advised that they should be removed.

Where RSPB Scotland considered that the management proposed would be beneficial for breeding waders, staff wrote a letter of support to accompany the bid for SRDP funding.

SRDP Results

Since the Clyde Valley Wader Initiative began in 2008 it has been involved in helping to bring 38 farms spread over 32 farm businesses and covering approximately 2000ha of the Clyde Valley into some form of management agreement for breeding waders. Around 98% of bids that were supported by RSPB Scotland were successful in acquiring SRDP funding and from discussions with case officers assessing the funding bids, the letters of support provided by RSPB Scotland were extremely useful in providing confidence that the money was going to be directed to appropriate areas.

Importantly, for the rural economy and for the decision-makers that see this as a priority, the bids supported by RSPB Scotland brought approximately £1 million into the area (based on per hectare payments over the five year period for which SRDP ran). Because breeding waders tend to favour less

intensive farmland (Stillman et al. 2006) many of the farms involved in CVWI are likely to be described as marginal within the farming system. This makes SRDP funding even more important in sustaining the farmed landscape.

Limitations of SRDP

Whilst the ‘Farmland Waders’ package of the RDC was welcome, the uptake of the range of management methods for waders was minimal on the farms in the CVWI and largely focussed on limiting grazing at certain times of year. Few farms opted to undertake more ‘active’ work for waders, such as scrape creation, ditch re-profiling or culvert breaking (to rewet drained areas), which enhance the value of the farmland by providing feeding opportunities for waders. Anecdotally, this was because they were not eligible for payments or those offered were not sufficient for it to be worthwhile. A further limitation was that despite having areas holding good numbers of breeding waders, some farms in the Clyde Valley could not achieve enough points on the RDC scoring scheme to make a bid worthwhile.

Results and monitoring

A programme of monitoring was established in 2012 in order to assess the effectiveness of the management. Farms are surveyed every three years using the O’Brien and Smith method for censusing lowland breeding wader populations. In summary,

this involves three visits at least one week apart between 15 April and 19 June, with surveys mostly being carried out within three hours of dawn (Gilbert et al 1998). Habitat data is captured on a field-by-field basis, and surveyors record sward length, ground moisture, area of rush pasture and management of rush pasture. Fixed-point photography is also used to help monitor changes in sward structure and surface water cover. As well as recording changing bird numbers and habitats, these surveys are also useful for RSPB Scotland to keep in contact with farmers and discuss any issues which may arise that could influence local or national management. The farms were grouped together into five main areas.

In 2012 volunteers surveyed approximately 1,000 hectares of farmland and recorded 186 pairs of breeding waders. When tallying up the numbers across all five groups of farms, 63 lapwing, 49 curlew, 44 oystercatcher, 19 snipe and 11 redshank breeding pairs were recorded. Recording snipe accurately can prove difficult due to their secretive nature, and there is always the possibility that snipe may be under-recorded in wader surveys. The figures in Table 1 will be used as the baseline population sample. We will compare surveys of the same sites in future years with these figures to provide information on the population trends across the project area.

Site name	Lapwing	Curlew	Oystercatcher	Snipe	Redshank	Total
Watermeetings to Elvanfoot	24	22	20	7	5	78
Tarbrax	7	7	2	6	0	22
Eastertown	12	6	6	1	0	25
South Medwin	4	2	3	0	0	9
Duneaton Water	16	12	13	5	6	52
Total	63	49	44	19	11	

Table 2. Breeding pairs at CVWI sites.

	Lapwing	Curlew	Oystercatcher	Snipe	Redshank
Guideline Breeding Density for Site to be of National Importance	16.8	7.5	10.1	6.1	3.6
Watermeetings to Elvanfoot	7.3	6.6	6	2.1	1.5
Tarbrax	2.7	2.7	0.8	3.0	0.0
Eastertown	5.7	2.8	2.8	0.5	0.0
Duneaton Water	10.2	7.6	8.3	3.2	3.8

Table 3. Breeding densities (breeding pairs per km²) at CVWI sites.

Breeding Densities

By knowing the area of the different sites, the breeding densities can be calculated by dividing the number of breeding pairs by the area surveyed. The work by O'Brien and Bainbridge (2001) produced guidelines to help determine whether a site could be considered of 'national importance', by producing 'density thresholds' for each species.

Table 2. shows (a) a breakdown of the total number of breeding pairs of the different species at each site (b) the total number of breeding waders of all species at each site, and (c) the total number of breeding birds of each species across the entire survey area.

Table 3 shows the density of breeding pairs at each site, compared to the guideline densities for nationally important sites. Instances where the density on the site exceeds the guideline density are shaded in grey. So, the Duneaton Water site is of national importance for breeding redshank and curlew. The South Medwin site has been omitted because it constituted a relatively small survey area: sites need to be larger than 1km² to provide reliable density estimates.

CONCLUSIONS

Breeding waders are in decline across the UK. The Clyde Valley Wader Initiative has used applied ecology to identify important areas for this group of birds and inform what management needs to be maintained or put in place to ensure their numbers are stabilised or increased. By working with SAC, RSPB Scotland has been able to positively influence land management for waders across a sizeable area of land. Ongoing monitoring of the farms in the Clyde Valley Wader Initiative will help to establish whether the management is proving effective and if necessary make adjustments to optimise it in the future.

The surveys have confirmed that some areas within the CVWI project host nationally important breeding densities for certain species (curlew and redshank). We are only sampling a handful of sites so there will likely be other areas also supporting nationally important densities. Some sites fell just below these thresholds. It is important to bear in mind that these thresholds were based on population and site data from the early 1990's. All farmland waders (except snipe) have declined considerably since then, so the density threshold for a site to be of national importance will have changed and will now be based on lower densities.

CVWI has proved a useful advocacy tool in demonstrating how conservationists can work positively with the farming community.

NEXT STEPS

The farms that were successful in obtaining SRDP funding will continue to be paid for undertaking management for five years. Following this, it is hoped that there will be a new round of funding that will continue to support the measures within the 'Farmland Waders' package and ideally make improvements to the requirements. In the meantime, RSPB Scotland has a small amount of money provided by Community Windpower to pay for additional measures, such as scrape creation that are not funded by SRDP or target farms that hold waders but did not enter in to RDC. Staff are currently liaising with farmers to deliver this. RSPB Scotland will continue to undertake monitoring of the sites.

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Giant docks and tiny dinosaurs: RSPB Loch Lomond

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RSPB Loch Lomond is 237ha of mixed wetland habitats and farmland within the flood plain of the

Endrick Water. Situated on the southern shores of Loch Lomond it forms part of the Loch Lomond National Nature Reserve and is a Site of Special Scientific interest, Special Area of Conservation, Special Protection Area, and a Wetland of International Significance under the Ramsar agreement. The site came into RSPB ownership in spring 2012 after generous donations from supporters of the RSPB, The National Heritage Memorial Fund, Scottish Natural Heritage (SNH) and The Loch Lomond and The Trossachs National Park (LLTNP). The management of the site is through a partnership with RSPB Scotland, SNH and LLTNP and it is hoped that through careful management the site can give a home to nature and a place for people to be with nature.

The broad range of habitats is one of the features that make the site so special. Sitting on the highland boundary fault means that there are species represented at their most northerly range and others at their most southerly range. The Endrick Water is an obvious feature of the site and has a large impact on hydrology and morphology. Despite being, only about 50km long it deposits an estimated 13,800 tonnes per annum of silts and gravel extending and reforming The Ring Point: a 1.6km bar created as the Endrick water meets the Loch (Mitchell 2001).

One of the key species of this river is *Lampetra fluviatilis*, river lamprey. Lamprey are a primitive family of jawless fish whose fossil record stretches back over 450 million years ago (making it the tiny dinosaur of the title). The population in the Endrick is unique in the UK for its unusual behaviour. River lamprey are a migratory species and spawn in freshwater. After about two years the young leave the rivers and head out to estuaries to reach maturity. The river lamprey in the Endrick differ in the fact that they do not mature in the saline waters of the Clyde, they remain in the freshwaters of Loch Lomond where they feed mainly on another special species of the area *Coregonus lavaretus*, powan (Maitland 2007). Another species unique to the area is *Rumex aquaticus*, Scottish or Loch Lomond dock. As the common name suggests, within the UK, this species is limited to Loch Lomondside. Despite reaching heights of over 2m (taller than your average botanist) it was not described as species in the UK until 1935.

Away from the Endrick but still sustained by its flow are the fens and meadows of the site, these support a wealth of wildlife including a nationally important wintering population of *Anser albifrons flavirostris*, Greenland white-fronted geese, *Lutra lutra* otter, breeding wading birds like *Gallinago gallinago* snipe and a diverse and often specialised group of invertebrates like *Donacia aquatica* zircon reed beetle and *Hydroporus rufifrons* ox-bow lake diving

beetle. Special mention must be made of the flora in these areas where diversity is particularly high: one 20 acre meadow alone supports approximately 120 species of vascular plant. Away from the wetlands but still pretty damp are the woodlands including Atlantic oak woodland. These woods are tremendous mix of young, old and decaying trees providing great opportunities for birds, invertebrates, bryophytes, lichens and fungi. As well as an existing wealth of wildlife the site has potential for re-colonisation by a number of species including *Sciurus vulgaris* red squirrel and *Avicola terrestris* water vole. With *Castor fiber* beavers being seen in the wider countryside these too could be a regular sight in years to come.

Despite the site having been a NNR since 1962 there are still threats. The change in farming since the 1930's has had a big impact on some of the meadows and fens. As an example Aber Bog, a fantastic 24ha area of would have been cut in rotation by local farmers, the bog hay would have been removed and used as winter bedding for livestock. This practice stopped in the 1930's and has seen a change in structure and diversity of the flora within this area. Recent attempts to manage the fen by cutting with specialist machinery has had mixed success with the biggest issue being the removal of cut material. One of the challenges as we go forward with site management will be how to reinstate sustainable management in areas like this.

A key management decision will be whether to reinstate close control of hydrology through ditch management and sluices or to try and follow the ambitions of the water framework directive (2000) with a more natural, non-intervention approach. This is a key discussion during the current production of a new management plan for the site.

Grazing is a key tool for the favourable condition of the fens and this is why the purchase of the site included some of the higher non-designated grazing pasture. This will allow an effective grazing regime to be established. This still needs to be supported by good infrastructure on the ground and this is another challenge for the coming few years.

Over the past ten years a lot of time has been spent on control of invasive non-native species. Across the wider NNR this has included both mammalian and botanical. The main focus on the Endrick floodplain has been with plant species such as *Impatiens glandulifera* Himalayan balsam, *Fallopia japonica* Japanese knotweed, *Heracleum mantegazzianum* giant hogweed and *Lysichiton americanus* American skunk-cabbage. The main impact of these species is to out compete native flora for space but evidence is suggesting that some species may out compete native flora for pollinators (Chittka et al 2001 and Dietzsch 2011). It is clear that this will continue to

be a focus for work on site but will also need to be considered as part of a catchment wide approach.

Current work is focused on production of a five year management plan. During the process, it has become clear that despite a relatively good historic level of wildlife recording this has not been consistent. One of the challenges has been collecting recent records for some of the rarer species and we have already discovered unrecorded species such as *Bagous lutulentus*, (Gurney 2013) a weevil of wetland habitats (this record is only the second record in Scotland for a hundred years).

People are going to be a big part of delivering conservation objectives at RSPB Loch Lomond. This is where field naturalists and other volunteers will be key to the site's success. It is also the ambition of the partnership to bring visitors closer to the wildlife of the area. This will be achieved gradually in a planned way to ensure that the wildlife comes first and RSPB Loch Lomond provides a great home for nature.

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Bringing beavers back

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Scottish Beaver Trial

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The comeback of the Eurasian beaver (*Castor fiber*) can be described as a real conservation success story. Reduced to an estimated 1,200 individuals by

the end of the 19th century predominately through over-hunting, this species has recovered across most of its former native range in Europe through active conservation measures from hunting bans and protection, to proactive translocations and reintroductions (Nolet & Rosell 1998, Halley & Rosell 2002). The success of such measures has resulted in a current population estimate of over 1 million individuals (Halley *et al.* 2012). Several reasons are often cited as to why so much effort has been invested into bringing beavers back. As a former native removed through human actions many believe we have a duty to implement its restoration, and there is a real public desire to do so, which of course is greatly aided when dealing with a charismatic mammal! The European Habitats Directive implies a legal responsibility to at least investigate the restoration of this species within member states where it was previously native. However, most importantly there is significant evidence that beavers and their associated activities generate more complex and dynamic wetland environments (see Rosell *et al.* 2005 for review)

The concept of beaver reintroduction is not new to Britain (see Jones *et al.* 2013). After its extinction in the 16th century small numbers of beavers have been imported, bred in captivity and even released at various points from the 18th century onwards, but these never established as free-living populations. Conservation campaigns for a full beaver reintroduction have occurred at various points but serious discussions began in the 1990's resulting in an application for a trial reintroduction by Scottish Natural Heritage in 2002, which was rejected by the Scottish Government in 2004. The next few years saw credible feasibility studies undertaken in England and Wales (Gurnell *et al.* 2008, Jones *et al.* 2011), and the successful application for a trial release by the Royal Zoological Society of Scotland and the Scottish Wildlife Trust in 2007 led to the establishment of the Scottish Beaver Trial in 2009 following a change in government in Scotland. More recently it has become evident that an unlicensed beaver population has become established on the Tayside river catchment (Campbell *et al.* 2012) and significantly the Scottish Government announced in 2012 that their presence will be tolerated until the conclusion of the official trial in Knapdale, Argyll.

The positive habitat creation and biodiversity benefits created by beavers are exemplified by key activities such as tree felling with the associated opening in the tree canopy spurring vegetation growth and plant biodiversity, and also the creation of dead wood providing breeding and feeding sites for a host of invertebrates and their predators. Dam building creates new wetlands, slowing water to encourage invertebrates, providing spawning ponds for fish and amphibians. These activities along with beaver burrowing behaviours all serve to create a

more complex and dynamic environment for numerous plant and animal species.

Such activities may conflict with human land-use, especially in highly modified landscapes. Burrowing and dam building tend to generate the most significant conflicts and irritation. However knowledge of beaver behaviour and ecology can be used to try and reduce the impact of such conflicts. Human-beaver conflicts tend to occur in and around freshwater bodies, the vast majority of which tend to occur within 20 metres of the water's edge. The creation of 20m buffer zones around water courses and bodies can serve to greatly ease such impacts. Long-term changes in land practices such as not farming to river edges or canalising water ways would also greatly benefit many other species.

Along with biodiversity benefits the ecosystem services beavers can provide such as water purification and water management are particularly evident in dry seasons in Canada for example (Hood 2011). Beaver ponds also act to retain silt and trap nutrients, and these ponds in turn can develop into very fertile beaver meadows when eventually the beavers move on and the dam breaks down dropping water levels. Also the potential positive socio-economic benefits that beaver tourism could bring at a local level should not be ignored (Campbell *et al.* 2007).

Over 26 European countries have already reintroduced the beaver, and experience from these countries has shown that this is a species that will need management, especially in heavily modified landscapes. But for such management solutions to work they need to be pragmatic. Beaver reintroduction will require compromise not only by landowners but also by conservationists and this will require education and experience with beavers in a British context. Ultimately, after such a long absence we need to learn to live with and manage this species again.

So what happens next? There is a strong drive for a full beaver reintroduction and it is increasingly evident that there are free-living beavers present in parts of Scotland and in England to a lesser extent, which are generating scientific, media and tourist interest. However, there are also strong arguments being presented by those opposed, many of which are currently being investigated in a Scottish context through the work of the Scottish Beaver Trial and the Tayside Beaver Study Group. 2014-2015 will see the conclusion of the Scottish Beaver Trial along with information from the Tayside beaver population being gathered by SNH and presented to the Scottish Government, who will then make the decision on whether beavers will remain in Scotland or not. In conclusion there has been a complex history of how beavers have

returned to Britain. Ultimately the decision for them remaining will be a socio-political one, as supposed to an ecologically based decision, with the next two to three years being critical for the future of beavers in Britain, so watch this space.

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Impact of the New Zealand flatworm on Scotland's biodiversity

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The detrimental impact of the New Zealand flatworm (*Arthurdendyus triangulatus*) on both Scotland's above and below ground biodiversity, could in certain parts of the country be considerable. Below ground earthworms play a crucial role in the ecology of many soils as they have a beneficial impact on nutrient cycling, drainage and soil structure while above ground they are a major constituent of the diet of many birds and mammals.

In much of Scotland, earthworm populations are likely to be missing or low in Scotland as many of the soils have a low pH (below that tolerated by earthworms) or the soils are intensively cultivated especially in the east of Scotland (Boag *et al.*, 1998). However, in fields where grass is the main crop, then earthworm numbers can be high (Boag *et al.*, 1997). Jones *et al.*, (2001) studied the impact of the New Zealand flatworm on the composition of the earthworm community in two New Zealand flatworm infested sites and compared these with flatworm free sites in western Scotland and found the numbers of both endogeic and anecic earthworm species were significantly reduced. Experimental research in Northern Ireland has confirmed that the numbers of the anecic species *Lumbricus terrestris* were significantly reduced as was the total biomass of earthworms (Murchie & Gordon, 2013). The indirect impact of reduced earthworm numbers on the size and composition of the populations of other creatures which inhabit soil e.g. collembola, nematodes, enchytraeids and fungi and bacteria have never been investigated.

Alford *et al.*, (1985) did a comprehensive inventory of the above ground animals which feed of earthworms and concluded that where the New Zealand flatworm became established it may lead to the extinction of moles (*Talpa europaea*), and possible local extinction of common shrew (*Sorex araneus*), badger (*Meles meles*), hedgehog (*Erinaceus europaeus*) stoat (*Mustela erminea*) but that foxes (*Vulpes vulpes*) would probably be unaffected. What little evidence we have so far suggests these predictions may be true since in fields in the west of Scotland where moles were once plentiful but have become infested with the New Zealand flatworms moles have been eradicated (Boag & Yeates, 2001). Alford *et al.* (1995) also predicted that there would be a detrimental impact on a number of bird species. At present no research is being undertaken to ascertain the direct or indirect impact of the New Zealand flatworm on Scotland's above or below ground biodiversity.

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How does an introduced vertebrate host species affect the risk of Lyme disease?

Characterising Grey squirrels (*Sciurus carolinensis*) as tick hosts and reservoir hosts of *Borrelia burgdorferi* s.l. in Scotland

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Lyme borreliosis caused by *Borrelia burgdorferi* sensu lato (*B. burgdorferi* s.l.) is a tick-transmitted bacterial zoonosis which is maintained in a complex tick-wildlife cycle. In Scotland, Lyme borreliosis is of increasing concern as numbers of human cases have risen sharply in the last decade. The introduction of a competent reservoir species may modify local disease dynamics and increase the risk of Lyme borreliosis to humans, by increasing the number of infected ticks in an area.

Grey squirrels (*Sciurus carolinensis*) were introduced to the UK approximately 100 years ago and have become widely established. The current population is estimated at over one million with at least 200,000 grey squirrels present in Scotland (Fig. 1). Previous research on a small number of

animals has shown that they are competent reservoir hosts for at least two genospecies of Lyme disease, *Borrelia afzelii* and *Borrelia burgdorferi* sensu stricto. So far the role of grey squirrels as tick hosts and *B. burgdorferi* s.l. reservoir hosts in Scotland has not been quantified.

Research objectives are to; 1) Quantify and characterise the tick parasite community of grey squirrels. 2) To quantify the prevalence of *B. burgdorferi* s.l. infection in grey squirrels by testing both tissues and by xenodiagnosis (testing tick larvae which have fed on squirrels). 3) To carry out objectives 1 & 2 at regional and national scales in Scotland. 4) To quantify the genetic diversity of *B. burgdorferi* s.l. from grey squirrels using multilocus sequence typing (MLST).

Preliminary results indicate that infection prevalence in squirrels is much higher than in native rodent species, and that squirrels are infected with a diverse range of species of *Borrelia*, confirming this species potential role as a reservoir host for *B. burgdorferi* s.l. in Scotland. Squirrels are frequently infested with larval and nymphal stages of *Ixodes ricinus*, also known as the deer or sheep tick (Fig. 2) and the main vector of Lyme borreliosis in the UK. Further analysis is underway to understand the spatial, temporal and host drivers of *Borrelia* infection in grey squirrels.

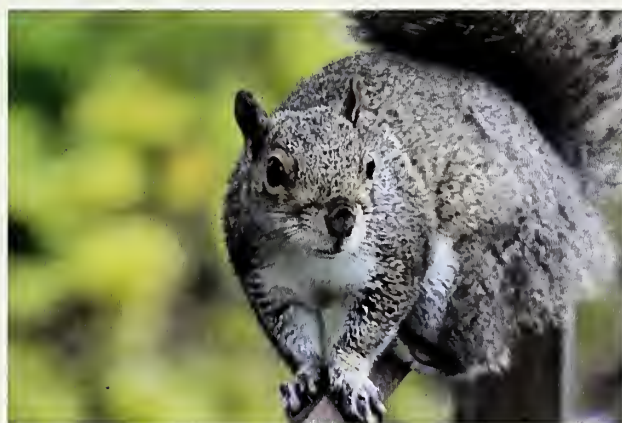


Fig.1. Grey squirrel (*Sciurus carolinensis*). Photo credit: Aileen Adam.



Fig. 2. *Ixodes ricinus*, adult female. Photo credit: Christina M. Berry/ University of Bristol.

Murder in the Eyrie: a behavioural study of a native species

1950s Golden eagle *Aquila chrysaetos* photographs by Charles Eric Palmar

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My father Charles Eric Palmar was the Curator of Natural History in the Kelvingrove Art Gallery and Museum, Glasgow from 1949 till 1984.

Although his speciality was ornithology, he was an all-round naturalist, being a member of the Scottish Ornithologists Club, the RSPB and the Glasgow Natural History Society.

He travelled all round Scotland from 1947 to 1986, taking many black and white negatives and colour slides, 16mm cine films and sound recordings, mainly of natural history subjects.

By careful study from a distance, note-taking and patient field-craft, he managed to get quite close to many of his subjects, without frightening them. He would never disturb a bird at the nest in such a way that it deserted.

He would build a hide, sometimes on the most precarious of cliff ledges, over a period of a few weeks, camouflaging and raising the height of the hide and moving it closer to the nest in a very gradual process. As a result, he obtained images which now need a schedule 1 licence, or could only be emulated by using modern long lenses. Nearly all his comprehensive and high quality collection has been painstakingly catalogued manually over a period of many years.



Photo 1. The pair of Golden eagles at the nest, with a downy youngster also visible



Photo 2. The older chick attacks the younger



Photo 3. Remains of the dead chick below the Eyrie



Photo 4. The surviving chick at 2½ to 3 weeks



Photo 5. The surviving chick at 7 weeks, now growing its flight feathers

WORKSHOP

Can ethical analysis contribute to policy and practice development in wildlife conservation?

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INTRODUCTION

Wildlife conservation is partly a science but, as soon as we ask what should be conserved, how and why, our answers are influenced by ethical considerations. In the case of the conservation of animals, a major factor is welfare and a confounding factor can be human perceptions of the value of particular species. An obvious contrast is the reaction of people to the culling of hedgehogs on the Western Isles compared to the culling of rats on Ailsa Craig.

The workshop began with a short account of ethical analysis and the way this can be applied to issues facing nature conservationists and animal welfare biologists. Participants were then divided into small groups each to tackle and report back on a particular case (see below). Groups were asked to include the following components in their analysis:

- Individual welfare
- Species welfare (effects on **all** species involved need considered)
- Financial costs of any action (these have an ethical dimension because high costs can limit actions on other projects)
- Effects on the public
- Priority evaluation (again, has an ethical dimension because of effects on other projects)

For each component, participants were asked to try to quantify on a scale from high to low. For example, culling a large number of invasive mammals would be ranked highly harmful to individual welfare, but could be mitigated by using a humane culling procedure. The workshop was run twice with nine participants each time.

CASES

1. Re-wilding Scotland

Human activities in the past have often led to the local extinction of animals previously common. For examples, beavers disappeared from Scotland by the 16th Century as a result of excessive hunting. Beavers have recovered their numbers elsewhere in Northern Europe, as a result of active conservation efforts. Beavers were re-introduced to Scotland in 2009. Other candidates for re-introduction include bears, wolves and lynx. Some refer to such efforts to restore populations of locally extinct animals as “re-wilding”. N.B. For follow-up reading, see Rubenstein *et al* (2006) for a critique of re-wilding proposals in North America., from ethical and ecological view points, and Sandler (2010); and Huynh (2011). As part of your discussion, consider whether you should re-introduce parasites of species you are restoring to an area, as well as the species of interest (Moir, 2012).

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2. The grey squirrel/red squirrel interaction

Another of our workshops covers this topic: here, we can concentrate on an ethical analysis. Grey squirrels are certainly an introduced species in Scotland and they are successful and invasive. They are carriers of squirrel pox but the disease does not kill them: it can be fatal for red squirrels. Red squirrels have reduced in numbers and distribution for a number of reasons, including competition from greys and disease spread. In towns and cities in Scotland, grey squirrels are the wild small mammals most people are likely to encounter: they are very popular with families in parks because of their inquisitive behaviour.

3. Threats to genetic integrity

We tend to learn in school that members of different species do not inter-breed, and if, rarely, they do, then they do not produce viable offspring. However, this is a simplification, especially in plants, where inter-specific hybridisation is common. In animals, successful hybridisation can occur between species that would normally not encounter one another in the wild, as a result of human interference. In Scotland, two examples of this have caused a conservation problem:

- Red deer and sika deer: sika deer originate from Japan but have been kept (and escaped from) deer parks in Scotland since the 19th century. They hybridise readily with red deer.

- Scottish wild cat and feral domestic cats. The domestic cat is derived from the Middle East, but if they return to the wild in Scotland, they hybridise easily with wild cats.

The offspring of these hybridisations have a mix of parental genes and some people regard them as a threat to the genetic integrity of the native species.

4. Triage

Triage is a system widely used in the health service for rapidly assessing priorities as patients are admitted to hospital. Since funds available for wildlife conservation are limited, some conservationists have suggested we need a triage system in conservation, where we divide species into three categories.

- Top priority for conservation
- Medium priority: conserve if funds allow
- No need to put effort into this group.

But what criteria would we use to place species into these categories? See Ochoa-Ochoa (*Biol Cons* 144, 2710 2011) for an explicit use of triage with respect to amphibian conservation in Mexico – but with no ethical content. Should we have such a system for wildlife conservation in Scotland, and if so consider the ethical criteria we might use to divide species into the three categories.

5. Coping with invasive alien species

Examples of alien species can be disease organisms (such as chytrid fungus which affects amphibians), plants such as *Rhododendron ponticum*, Japanese knotweed, Himalayan balsam etc; or animals in the wrong place such as hedgehogs on the Outer Hebrides; or escaped farmed animals like mink, signal crayfish.

Natives, Aliens and Reintroductions: Closing Remarks

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We have had a very full and varied day, and I am not going to attempt to summarise all the talks in just a few minutes. The conference proceedings will be published in *The Glasgow Naturalist* and that will provide an opportunity for participants and the

wider conservation and natural history community to reflect on the contents.

I'd like to thank all the speakers for providing such a fascinating and highly accessible set of talks on our various themes. We heard extensively about alien species: from Chris Smout, how do we define aliens, a magisterial historical perspective; then contrasting views on alien plants – from Jim Dickson (summary: many do no real harm) and Stuart Brabbs (the costs and effectiveness of eliminating invasive riverbank aliens); from Stan Whitaker, law and practice in dealing with aliens not all of which are invasive. The law in Scotland now defines native species according to their natural range, rather a problematic concept, given the dispersal abilities of so many species. On alien animals, Zara Gladman covered the rapid invasion of the North American signal crayfish but also the oddity that the white-clawed crayfish is not a native to Scotland but is in England and because it is threatened there, the two introduced Scottish populations are protected.

On re-introductions, we heard about the Scottish beaver trial but also about more local "re-introductions" where threatened fish populations have been successfully introduced to new lochs (would this count as an alien invasion under the new law?).

On natives under threat, we heard about studies and conservation schemes involving the chequered skipper butterfly, wild pollinators and farmland waders. This theme also included the great opportunity provided by the establishment of RSPB Loch Lomond, a nature reserve with huge potential for the protection of a wide range of native species. Another theme was public attitudes to wildlife: the badger cull has just begun in England, though not planned for Scotland. But Andy Riches showed that badger baiting is surprisingly common in Scotland. Probably the most depressing contribution (though entertainingly presented) was Stephen Woodward's account of the new pathogens spreading to attack our forest trees.

Finally, a personal note: I found it wonderful that we were able to hear authoritative talks from three recent Glasgow Zoology graduates: Ellen Rotheray, Roisin Campbell-Palmer and Zara Gladman, all of whom learned some of their fieldwork skills on University of Glasgow Trinidad expeditions. Postscript:

Chris Thomas, professor of conservation biology at the University of York, and a leading researcher into the biodiversity consequences of climate change, raised many of the issues covered in our conference in a short 'Nature' World View article (Thomas, 2013). He claims that the UK has gained rather than

lost from the arrival of non-native species, and that attempts to control species like Himalayan balsam, just because they are non-native, are 'a waste of effort'(echoing the conclusions of Jim Dickson's conference talk). In his view, scarce resources should be saved for controlling invasive aliens that are clearly damaging, such as rats and goats on oceanic islands. The transworld movement of species can increase not only local biodiversity but also biodiversity overall, since non-native species may change so much in adapting to their new habitats that they become novel species. New species may also arise through hybridisations between non-natives and related natives, especially in plants. Climate change will also have effects on biodiversity, some of them positive. Thomas concludes 'There are excellent arguments for conserving the wildlife we already have, but it is less clear why our default attitude to novel biodiversity is antagonism or ambivalence.' Well worth reading.

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FULL PAPERS

Clyde re-built: when will river invertebrate communities return to a pre-industrial condition?

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ABSTRACT

The River Clyde has been described in the past as one of the worst polluted rivers in Britain. Since then, considerable improvements in water quality have been made, which contributed to the return of Atlantic salmon to the river system in the early 1980s. Using long-term river invertebrate data collected over a 32 year period (1975 - 2006) by the Scottish Environment Protection Agency and computer generated predictions (River Invertebrate Classification Tool) of river invertebrate communities, we examined the historic and current biological status of the River Clyde and make predictions about the future condition of the river system. We found that river invertebrate community richness had significantly increased over the study period and that the River Clyde has the potential to reach a pre-industrial condition by the year 2020. Our results also highlight the importance of considering long-term change when investigating biological recovery.

INTRODUCTION

It is now 140 years since a Royal Commission Report highlighted the River Clyde as one of the most heavily polluted rivers in Britain (Hammerton, 1986). This report was the catalyst (albeit low energy) that drove national, regional and local government to pass legislation to help improve the condition of surface waters in Britain. Legislation and local efforts to enforce this legislation led to improvements in the water quality within the River Clyde catchment (Table 1), contributing to the return of Atlantic salmon (*Salmo salar*) to the river in the early 1980s (Hammerton, 1986). Thirty years have passed since this iconic moment, but has the river continued to improve and to what extent has the River Clyde recovered?

Measuring biological recovery is a complex process. The endpoint at which system recovery is deemed to have been achieved is highly dependent on the parameters used to assess system change. For

example, measurement of the abiotic conditions may indicate that a disturbed system has returned to a pre-disturbed condition in terms of the physical environment (e.g., availability of habitat, water chemistry) but there is invariably a lag in the re-establishment of the biological community (e.g., Ormerod & Durance, 2009). The choice of a biological parameter used to assess recovery is also dependent on the choice of organism, or group of organisms, as organism behaviour can also influence the interpretation of results. In river systems for example, fish are highly mobile and can move from areas they perceive as poor quality. Their presence in a river might therefore be only representative of the conditions at that instant. Freshwater macroinvertebrates (invertebrates that can be seen with the unaided eye), have been used as indicators of river health for a long time (Hynes, 1966). This group of animals show a wide range of tolerances to various polluting influences (Armitage *et al.*, 1983) and are relatively sedentary (*c.f.* fish). As such, macroinvertebrates provide a good indication of the prevailing abiotic (and biotic) conditions at a site.

To determine whether a system has recovered fully, an endpoint or benchmark must be selected against which to measure system change and a progression towards a pre-disturbed condition. A common approach is to make comparisons between sites that have, and have not been disturbed. This approach is of course dependent on the availability of comparable sites that have not been influenced by the disturbance being investigated. An alternative is to use a modelling approach, where the environmental characteristics of a system are used to make predictions about the community expected to be found at a site in the absence of disturbance. This approach has been used to predict for example, the composition of bird communities (Feria & Paterson, 2002), the likelihood of the establishment of invasive species (Gallardo *et al.*, 2011) and the composition of macroinvertebrate

communities in running water sites (e.g., Wright *et al.*, 1984); it is this modelling approach we use here.

Using biological information collected from across a river catchment previously impacted by industry over a 32 year period (1975-2006) and information generated from computer simulations, we examine the degree to which the River Clyde has recovered by investigating temporal changes to the macroinvertebrate community and make predictions about the time frame for biological recovery of the River Clyde.

METHODS

The River Clyde is located in west-central Scotland (between Lat: 56° N & 55° 30' N and Long: 004° 73' W & 003° 55' W). The catchment covers an area of 3125 km² with a total river length of 4165 km and 26 km² of freshwater lochs and reservoirs. Land use in the catchment is dominated by agriculture (45%) and natural and semi-natural habitats (37%) with urban land use comprising 18%, the remaining 1% being lochs and reservoirs (Fig. 1). Although urban land use does not dominate, in 2006 31% (1.6M) of the total population of Scotland lived within the catchment (General Register Office for Scotland Report, 2007).

Macroinvertebrate data have been collected from the River Clyde by the Scottish Environment Protection Agency (SEPA) and its previous incarnations since 1975, to monitor the water quality of the watercourse. The same standard three minute kick sample using a standard (1 mm mesh size) pond net has been used to collect biological samples since 1975 with the addition of a one minute hand search from 1990 (Doughty, R. *pers. comm.*). Collected material was preserved and later identified in the laboratory to the taxonomic level of family (see examples Plate 1). This information was then used to assess the biological condition of the river water at a site using the Biological Monitoring Working Party (BMWP) system (see Armitage *et al.*, 1983). We use these data to assess the biological recovery of the River Clyde.

Community richness was determined from the list of 82 macroinvertebrate families (but excluding the families Aphelocheridae, Brachycentridae, Goeridae, Lepidostomatidae, Odontoceridae, Psychomyiidae and Valvatidae because of taxonomic and recording issues at the start of the study period) that are recorded as part of the BMWP system (Armitage *et al.*, 1983). Community richness measured at the taxonomic resolution of family from the constrained BMWP list of scoring families has been shown to be a highly significant ($R = 0.854$, $P < 0.0001$) representation of species richness found at running water sites in Great Britain (Wright *et al.*, 1998).

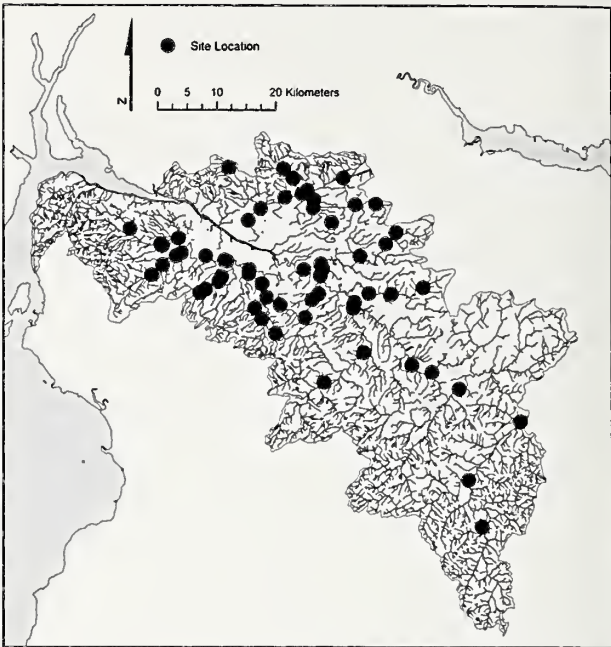


Fig. 1. Location of the 62 sites in the River Clyde at which invertebrate data were collected (2618 samples) over the 32 year (1975 - 2006) study period.

Table 1. Chronology of the River Clyde pollution abatement efforts (adapted from Hammerton, 1986).

Year	Event
1872	Royal Commission Report highlighted the River Clyde as one of the most heavily polluted rivers in Britain.
1876	Rivers Pollution Act enacted.
1895	Within the Clyde catchment Lanark County Council established as a pollution control authority to enforce the provisions of the Rivers Pollution Act, 1876.
1903	Lanark County Council pollution reports highlight improvements in domestic waste treatment, the 1924 report highlighted the shortcomings of the current legislation in allowing the county council to set effluents standards and take speedy legal action against polluters.
1909	
1924	
1927	Scottish Board of Health survey of river pollution highlighted the River Clyde as the worst affected with 235 'pollutions' of the 880 total in Scotland (the River Forth was next with 107 'pollutions').
1927	Secretary of State for Scotland appointed an Advisory Committee on Rivers Pollution Prevention.
1936	Special report produced by the Advisory Committee on River Pollution Prevention stated "we cannot over emphasise the serious situation that exists in many parts of the country on account of the gross pollution of river and have come to the conclusion that a satisfactory solution of the problems of rivers pollution is not possible under the present administrative arrangements".
1946	Secretary of State for Scotland appointed

	the Sub-committee of the Scottish Water Advisory Committee to recommend how to amend the law on river pollution.
1950	Sub-committee of the Scottish Water Advisory Committee report produced.
1951	Rivers (Pollution Prevention) (Scotland) Act enacted, which involved the setup of independent river purification boards.
1956	Clyde River Purification Board established.
1958	Chemist appointed to Clyde River Purification Board.
1960	First water chemistry samples recorded.
1965	Rivers (Pollution Prevention) (Scotland) Act revised.
1972	Clyde River Purification Board Act enacted, a local act was passed to control the discharge of pollutants underground and the extraction of minerals such as sand and gravel directly from the river bed.
1975	First biological water samples recorded.
1983	First run of Atlantic salmon in the River Clyde for over 120 years.
2000	Water Framework Directive, European Legislation requires EU states to achieve "good ecological and chemical status" in all waterbodies by 2015.

Macroinvertebrate information was available from 62 sites across the River Clyde catchment (Fig. 1). Generally, each site was sampled in spring (March to May) and autumn (September to November) each year for the study period, although there were some minor deviations from this pattern and data from 1991 to 1994 were lost in storage and not available for analysis.

River Clyde macroinvertebrate community richness change

To determine if there had been a significant change in the richness of the River Clyde macroinvertebrate communities, we used a mixed effects linear model to examine the relationship between community richness and year, including 'site' as a random factor (to account for pseudo-replication as sites were sampled multiple times over the study period).

Modelled community richness

To investigate the community richness for the River Clyde we would expect in the absence of human influence, we used a predictive model, the River Invertebrate Classification Tool (RICT; SEPA, 2012). RICT is a web-based application that can provide predictions (based on a few environmental characteristics) of the number and type of macroinvertebrate families found in a section of a river in the absence of human influence (Table 2). Originally developed under the acronym RIVPACS (River Invertebrate Prediction and Classification System), this predictive approach to water quality assessment was pioneered in the U.K. (Wright *et al.*,

1984) and has been accepted as a standard method in the European Union as part of Water Framework Directive (WFD; European Commission, 2000) monitoring (Logan & Furse, 2002) and has been developed for use in other countries worldwide [e.g. AUSRIVAS (Australia), Davies, 2000; SEPAC_{SRI} (Sweden), Davy-Bowker *et al.*, 2006; PERLA (Czech Republic), Kokeš *et al.*, 2006)].

In brief, the model uses community composition data collected from reference sites (i.e., river sites deemed to be of "very high" ecological quality, with minimal impact from human activity). Reference sites are grouped according to the similarities in the relationship between the environmental characteristics and the invertebrate community composition, and it is these reference groups that form the basis of the predictive model. Variables measured (Table 2) at a site are then used to predict which families are likely to present at that site given the local environmental conditions (see Wright *et al.*, 2000 and CEH, 2012).

For each of the sites, environmental characteristics required for RICT were derived from Ordinance Survey (OS) maps, field sheets and alkalinity data were provided by the chemistry department in SEPA. As sampling sites were chosen to represent the best available natural conditions (Doughty, R., *pers. comm.*) within river sections, site substrate (one of the environmental variables used in the model) was in relatively good condition and, the measured alkalinity (another model variable) in 2006 was unremarkable (87.3 mg L⁻¹ ± 9.5, 2 standard errors = 95% confidence interval) given the underlying geology (carboniferous rocks and coal measures; BGS, 1985). The remaining environmental variables derived from OS maps remain constant for millennia. We therefore defined model predictions based on the 2006 environmental variables as a benchmark against which to assess River Clyde community richness.

Table 2. Environmental variables used to determine community composition using the RICT system.

Variable	Unit of Measurement	Data Source
Location	National Grid Reference	OS maps
Altitude	m	OS maps
Distance from river source	m	OS maps
Slope	m km ⁻¹	OS maps
Discharge	m ³ s ⁻¹	SEPA
category	1 (< 0.31 m ³ s ⁻¹)	Hydrology
(9 categories)	2 (0.31 – 0.62 m ³ s ⁻¹)	Unit
	3 (0.62 – 1.25 m ³ s ⁻¹)	
	4 (1.25 – 2.5 m ³ s ⁻¹)	

	5 (2.5 – 5.0 m ³ s ⁻¹)	
	6 (5 – 10 m ³ s ⁻¹)	
	7 (10 – 20 m ³ s ⁻¹)	
	8 (20 – 40 m ³ s ⁻¹)	
	9 (40 – 80 m ³ s ⁻¹)	
Substratum characteristics (5 categories, summing to 100%)	% cover boulder/cobble (> 64mm); pebble/gravel (2-64 mm); sand (0.06 – 2 mm); silt/clay (< 0.06 mm)	SEPA field sheets
Stream width	m	SEPA field sheets
Stream depth	cm	SEPA field sheets
Sample season (3 categories)	Spring (March – May, incl. February) Summer (June – August) Autumn (September – November, incl. January & December)	
Alkalinity	mgL ⁻¹	SEPA chemistry unit

River Clyde recovery

We investigated the time frame in which the River Clyde has the potential to attain a community richness expected in the absence of human impact using short- and long-term measurements of contemporary community richness.

As a short-term assessment of the invertebrate communities of the River Clyde, we compared measured (sampled) community richness in 2006 with RICT modelled predictions of site community richness *i.e.*, the probable community richness of an un-impacted site (based on the environmental variables measured in 2006) for each of the 62 sites in a paired t-test.

To account for long-term change we extrapolated the results of the linear mixed model. The intersection of the regression line ($\pm$ 2 standard errors) and mean modelled community richness ($\pm$ 2 standard errors) (2006 RICT predictions) provides an indication of the period over which the River Clyde is likely to achieve a biological level akin to that expected in the absence of human mediated stress. All statistical analyses were performed in R version 2.13.1 (R Development Core Team, 2010)

RESULTS

Over the period from 1975 to 2006, 2618 samples were collected from 62 sites in the River Clyde

catchment. The mean number of families in a collected sample was 15.6 ± 0.2 (2 standard errors) (range 0 - 34 families) over the 32 year period.

River Clyde macroinvertebrate community richness change

Macroinvertebrate community richness increased significantly over the 32 year study period ($t_{(2618,62)} = 30.355$, $P < 0.001$; Fig. 2) and the regression equation took the form:

$$\text{Community Richness} = 0.214 * \text{Year} - 410.713$$

This approximates to a mean increase of one macroinvertebrate family every five years, within the River Clyde catchment over the study period.

Modelled community richness

The predicted, un-impacted, community richness supported at each of the 62 sites (determined using RICT) ranged from 19.1 to 27.9 families [mean 22.2 ± 0.3 (2 standard errors)]. Actual community richness measured from samples collected from the 62 sites in 2006 ranged from 9 to 31 families [mean 21.2 ± 0.8 (2 standard errors)]. The mean of the RICT modelled community richness and the mean of the measured (actual) community richness in 2006 were close to being statistically significantly different (paired t-test, $t_{(124)} = 1.805$, $P = 0.07$; Fig. 3).

River Clyde recovery

The intersection between modelled community richness and the extrapolation of the linear regression of macroinvertebrate community richness on year occurred at 2019.8 (range 2018.6 – 2021.2; Fig 2)

DISCUSSION

Since the Royal Commission Report, in 1872, there have been significant changes to legislation controlling the effects of human impact on U.K. river systems (Hammerton, 1986; European Commission, 2000). The results from this study have provided an insight into the long-term change of the biological state of a river recovering from industrial activity, as a result of the implementation of this legislation, and have highlighted the importance of accounting for historic change in assessing the recovery of a biological system.

Over the 32 year study period community richness in the River Clyde increased on average by one family every five years and represents an average addition to the River Clyde macroinvertebrate community by just over six families over the study period.



Plate 1. Some macroinvertebrates of the River Clyde. (a) Ephemeroptera belonging to the taxonomic family, Heptageniidae (genus *Ecdyonurus* pictured). Frequently found in rivers of good to high water quality, this family feeds in fast flowing river sections by scraping algae from the substrate surface. Species in this family are dorso-ventrally flattened to allow them to feed in the boundary layer. (b) *Bdellocephala punctata* a member of the family Dendrocoelidae (Tricladida). This family is indicative of good to moderate water quality has been described from a wide variety of habitats from still water to fast flowing river sections. This particular species is nationally uncommon, but is found in the River Clyde. (c) *Asellus aquaticus* (Asellidae) is an aquatic analogue of the terrestrial woodlouse (multiple genera). Asellidae are generalist detritivores and can tolerate very poor water quality. Pictured here is a ventral view of a mature female detailing a juvenile in the brood-pouch. (d) The leach *Helobdella stagnalis* is a member of the taxonomic family Glossiphoniidae and is easily identified though the presence of a chitinous scute (indicated by the arrow). (e) A trichopteran of the family Rhyacophilidae, *Rhyacophila dorsalis* is an active foraging predator found in clean fast flowing sections of river systems. This species is widespread throughout the River Clyde. (f) Some other species of predatory Trichoptera build nets and collect drifting material that becomes entrained. In this picture the water is flowing from the bottom of the picture and the animal inhabits the u-shaped section of the net.

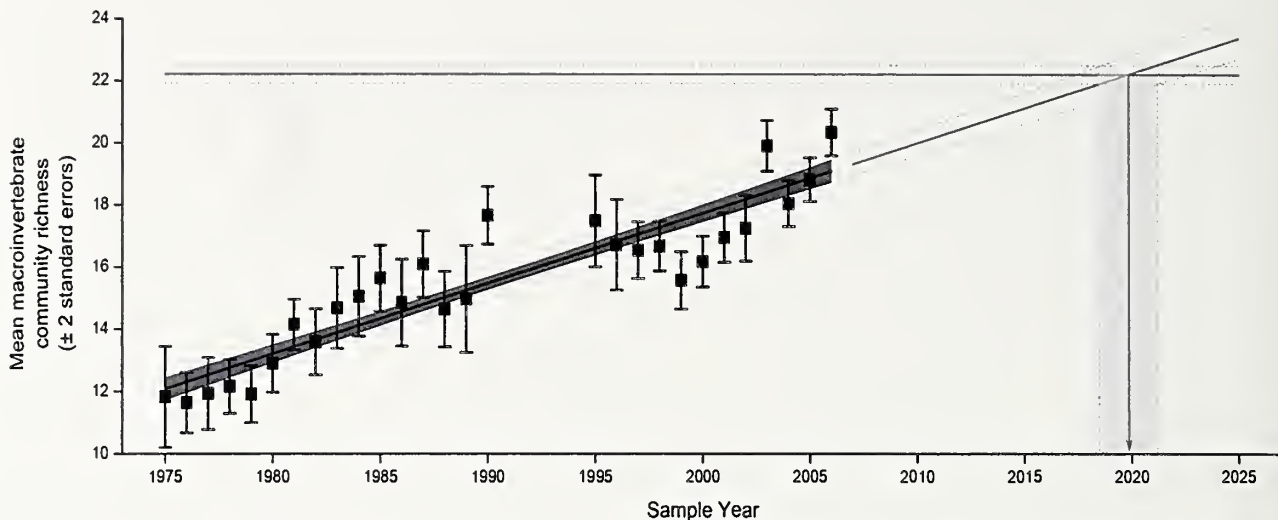


Fig. 2. Temporal change in community richness in the River Clyde over the study period. Mean collected community richness (black squares); regression line of community richness on year (black line); extrapolation of temporal change in community richness (grey line); mean modelled (RICT predictions) community richness (horizontal grey line); intersection of extrapolated mean and modelled mean community richness (grey arrow). All confidence intervals are 2 standard errors (= 95% confidence intervals).

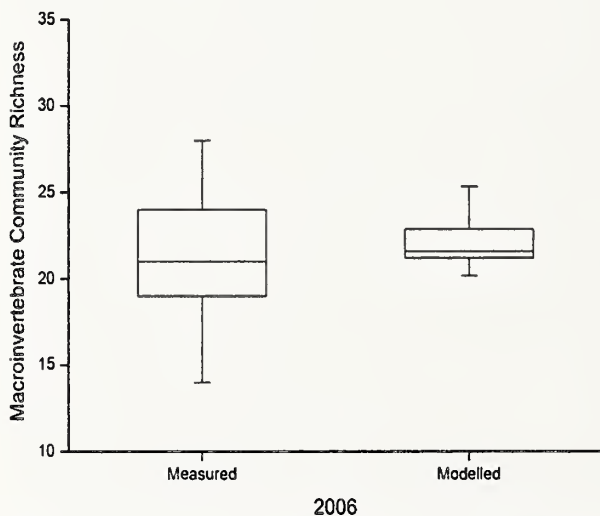


Fig. 3. Box [25, 50 (median) and 75 percentile] and whisker plot (5 and 95 percentile) of measured and modelled community richness in the River Clyde in 2006.

The increase in community richness within the River Clyde has arisen as a result of improvements to the chemical water quality (e.g., reductions in ammonia and suspended solids and increases in dissolved oxygen) and these changes have facilitated the colonisation of additional macroinvertebrate families through the opening of previously unavailable niche space.

How representative the rate of change in River Clyde community richness is in terms of ecological recovery of a river system is difficult to explain. Recovery trajectories are reliant on the ecological

parameter measured and the endpoint (at which recovery is deemed to be achieved) selected. In a review assessing long-term change in river systems Jackson & Füreder (2006) highlighted a lack of studies detailing change over longer-term periods (which they defined as greater than five years). In fact of the 236 sites identified in their review the majority (63%) were of 10 years or less.

Our study also highlighted the importance of considering historical changes when assessing recovery. Sampled community richness in 2006 in the River Clyde almost met the threshold for being significantly different than that expected in the absence of human impact (RICT predicted richness), and this snapshot of condition could lead to a conclusion that the river had recovered to a healthy state at that time. The inclusion of the pattern of ecological changes prior to 2006 shifts this conclusion by over a decade, indicating a healthy river state will not be achieved until 2020. These results highlight the importance of using data collected over biologically meaningful time scales that dampen the effects of short-term fluctuations.

The results from this study are encouraging for the biological recovery of the River Clyde. The ambitious aims set by the WFD, that all water bodies (with the exception of heavily modified water bodies) need to reach 'good ecological status' by 2015 (with the possible extension for another 12 years; European Commission, 2000), may be achieved within the River Clyde. There is overwhelming evidence from Europe that, even within the extended time period, many regions will struggle to meet 'good ecological status' by 2027

(Hering, *et al.*, 2010). The extrapolation of our result indicates that the River Clyde should be achieving target community richness by 2020, seven years prior to the 2027 deadline.

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Observations on a population of adders, slow-worms and common lizards on Loch Lomondside, Scotland

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ABSTRACT

A population of reptiles on the east shore of Loch Lomond, Scotland, was monitored intensively during 2012, to understand population numbers, distribution, movements and biology through the year. Numbers of European adders *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara* were detected. Animals were seen first emerging from hibernation in early March and watched until late October, with breeding biology and movements observed.

INTRODUCTION

Three species of reptile are native to Scotland, the European adder, slow-worm and common lizard, although a small, introduced population of sand lizards *Lacerta agilis* is present on Coll (Beebee and Griffiths, 2000), and there have been a few isolated observations of grass snakes *Natrix natrix* in southwest Scotland in the past and during the 2000s (Taylor, 1900; CARG, 2013).

All three native species are currently found throughout much of the country in suitable habitat, apart from Shetland, Orkney and the Outer Hebrides, although their distribution is patchy, being heavily influenced by human activities (Arnold, 1996; Reading et al 1996). The southwest of Scotland is a stronghold with the three reptiles present widely in Dumfries & Galloway, Ayrshire, Argyll and the Clyde areas, including some islands. Despite this little has been published describing the biology of these species in Scotland. Slow-worms have been studied on Ailsa Craig (McWilliam, 1925; Zonfrillo, 2000; Lavery *et al.*, 2004), and a few books and papers contain some interesting anecdotal information on slow-worms, adders and common lizards (White, 1877; Boulenger, 1892; Campbell, 1892; Dobbie, 1898a; Dobbie, 1898b; J.A. Harvie-Brown faunal series; Hinxman, 1902; Leighton, 1902; Service, 1902a; Service, 1902b; Morrison, 1924), with one containing details about Loch Lomond (Bidie, 1902). But there are no published studies based on intensive observations as have been completed elsewhere in the UK and Europe (Avery, 1962; Viitanen, 1967; Prestt, 1971;

Stumpel 1985; Neumeyer, 1987; Stafford, 1987; Smith, 1990; Riddell, 1996; Platenberg and Griffiths, 1999; Anderssen, 2003; Phelps, 2004a; Phelps 2004b; McPhail, 2011).

Hence, I decided to monitor a rich population of the three species on Loch Lomondside to gain information about their biology in a Scottish context. Reptiles had been observed occasionally at this site for many years, with the author seeing a few in 2011. But the size of the population was not appreciated until systematic fieldwork was completed during 2012; this paper describes the results of these studies.

METHODS

Study site

The study site is an area of south and west facing replanted native forest on hills flanking the east shore of Loch Lomond, at an altitude of 40-90 m; in total it comprises some 50 hectares. The habitat consists of a mosaic of birch *Betula* spp, rowan *Sorbus* spp and oak *Quercus* spp, interspersed with bracken *Pteridium* spp, gorse *Ulex* spp, bramble *Rubus fruticosus*, heather *Calluna vulgaris*, and other native plants. The site is fenced preventing the entry of deer, and is consequently rich in native fauna and flora. It contains areas of exposed granite and mica schist rock, slopes and boggy areas, with a burn along its northern edge. The lower parts were once a sheep-farm. Many original stonewalls have collapsed, which have subsequently been grown over by bracken, bramble and gorse; these piles of covered rocks have created hibernacula suitable for reptiles. An area near to the farm buildings, particularly good for reptiles, is illustrated in Fig. 1.

Survey work

With the permission of the landowners up to 30 artificial refugia, made from roof matting, were placed at suitable places throughout the site on 11 March 2012, following ARG procedures (<http://www.arguk.org/recording>), with each refugium numbered and its position identified with a global positioning system (GPS) device. These were inspected visually about once a week through

most of the year until late October, typically from 8-10 am on sunny or warm days, though sometimes later if dictated by the weather. Weather conditions and air temperature were recorded on each visit. The number, approximate age (based on size), and the gender of adders, slow-worms and common lizards was noted at, and in the vicinity of, each mat, by visual inspection. The gender of adders can be determined by their background colour, with males grey and females brown; female slow-worms have dark flanks and a dorsal line, with males a more uniform colour; male lizards are distinguished from females by brighter belly colours, a vertebral line made up of spots as opposed to a line, a larger head and swelling around the base of the tail (Beebee and Griffiths, 2000).

Individual adders were recognised through a combination of photographs of head patterns, which are unique to each individual (Sheldon and Bradley, 1989; Benson, 1999; Garbett, 2008; Sheldon and Bradley, 2011), and by repeated observations of individuals at sunning locations; this allowed actual numbers to be estimated. In contrast, actual numbers of slow-worms and common lizards were not estimated, as it was often found to be not possible to identify individuals from visual

inspection; published methods require handling (Riddell, 1996), which was not attempted. These, instead, were counted as total observed counts, so-called “reptile days”. Additionally, the locations of hibernacula and regular sunning positions were mapped.

RESULTS
Population numbers

The combined results of the survey work during 2012 are shown in Table 1 and Fig. 1. These show the numbers of reptiles seen during the year, and the distribution of reptiles at one part of the survey area, which had the highest density of animals. In total 40 individual adders were counted: 15 males, 24 females and one juvenile. Many were seen on multiple days, which corresponded in “reptile days” to 55 males, 92 females and two juveniles. Slow-worms and common lizards were only counted as “reptile days” and these corresponded to 83 and 26, respectively. For slow-worms, this comprised 25 males, 36 females, 15 juveniles and 7 sex undetermined; for common lizards this comprised four males, two females and 20 sex undetermined. The maximum day counts of slow-worms were four adult males, seven adult females, and 10 juveniles; the maximum day count of common lizards was six.



Fig. 1. Distribution of adders *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara* observed on the east shores of Loch Lomond, Scotland. This area formed only part of the total survey area at the site, but was particularly rich in reptiles.

Table 1. Numbers of adders *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara* observed during 2012 at a site on the east shores of Loch Lomond, Scotland.

	adder			slow-worm				common lizard		
	♂	♀	juv	♂	♀	juv	?	♂	♀	?
March 11								1	2	
18	3	2	1	1				2		2
22	4	3	1	1				1		
26	2	1		1						1
30	5	4		3						
31	7	4		4	1		1			6
April 1	4	2			2					
14	9	2		2	2					
15	3	2								
22		2		2	1					
28		2		1						
May 2		1		1	2					
5		2		2	3					
12		7			1					1
20		3			4					2
June 2		1		1	3					3
18	1	3					6			2
19	1	4		1	2					1
20	2	1		1	3					
July 29	2	5				10				
August 3	1	4			7					
5		4			3	2				
7	2	5				3				2
16		4			1					
24		4			1					
26		4								
30	1	3								
September 4		2		2						
12		2								
19		2								
27	1	1								
30	3	2								
October 7	2	2								
14	1	1								
21	1	1								
Total days**	55	92	2	25	36	15	7	4	2	20
Total "estimated real"+	15	24	1							

- Counts of total numbers of observations
- + Counts based on identification of individuals

Annual cycles

Adders

Adders were first observed on the 18 March when both males and females of various ages were found, one week after the refugia mats were placed out. This was during a period of sunny, though cool, weather with an air temperature of 12°C. Through March and early April adders would sun for long

periods in locations immediately next to hibernacula, on multiple days. Up to 2-3 animals could be seen together (Fig. 2A), though typically single snakes were observed. Courtship and mating was observed in mid to late April (Fig. 2B). After this time the males and small females disappeared with only the large, mated gravid females remaining near the hibernacula (Fig. 2C). These would sun for

extended periods throughout the summer, even in cooler weather when they would flatten their bodies, to obtain maximum warmth from solar radiation (Fig. 2D), possibly to facilitate incubating gestating young (Vanning 1990). They only disappeared in early to mid September, likely to give birth, although this was not observed, and no young were found during this period. Occasionally,

males would be seen through the summer period, but transiently at new locations, indicating that they were wandering. Males and small females reappeared in numbers in mid September at hibernacula, sunning for long periods, with the last seen on 21 October.



Fig. 2. a) Male and female adders *Vipera berus* (~40 cm in length), recently emerged from hibernation, 31 March 2012. b) Mating male and female adders (both ~60 cm), 15 April 2012. c) Gravid female adder (~60 cm), 22 April 2012. d) Gravid female adder (~60 cm) in a flattened posture to maximise absorbance of solar radiation, 20 June 2012. e) Gravid female slow-worm *Anguis fragilis* (~25 cm) found under a refugium mat, 25 August 2012.

Adders were found to be remarkably site faithful, with many animals seen at the same sunning positions over periods of weeks and sometimes months. Sunning positions were usually in open areas next to bracken, bramble and gorse, where snakes could retreat upon disturbance. On disturbance adders would disappear to cover, but would invariably reemerge to the same location within 10-20 minutes. Snakes were most reliably seen on sunny, warm days between 8-9 am, but later in the day if conditions were less favourable. In warm or hot conditions adders would sun for just 1-2 hours before disappearing. Adders were noticed to be the most cold tolerant of the reptiles. Some appeared on days with air temperatures barely above freezing, and hoar frost present. Generally, they were not observed to use refugia mats, apart from one gravid female through the summer, and a juvenile seen in March (Fig. 3A). This juvenile was

the only young seen, and had presumably entered hibernation immediately following birth the previous autumn; it appeared to have hibernated with a male slow-worm. Ecdysis was observed on five occasions, from April to September, with four skins found. A further nine snakes were seen apparently about to undergo ecdysis, suggested by their cloudy, opaque eyes, and dark body colour.

Slow-worms

The first slow-worm was first observed on 18 March. Males were seen first, with females appearing two weeks later. Males and females were seen throughout the spring and summer, with incubating females found up to the 24 August (Fig. 2E). However, small young first appeared from mid July. Far fewer were seen through August, with the last observed on 4 September.

Slow-worms were invariably found under refugia mats. Typically they were not present at 8-9 am, but would be found at 10-11 am when the sun was on the mats, suggesting they were spending the night elsewhere and using the mat as a sunning tool. Upon disturbance, slow-worms would disappear by burrowing into the ground, but usually returned to the same place within 10-20 minutes. Many of the

mats had ant Formicidae spp colonies form under them; slow-worms have been found in ants' nests elsewhere in the UK, apparently exploiting the subterranean holes created by these insects (Beebee and Griffiths, 2000). Rarely, adults were found basking above ground: these were large, gravid females in early August, with just one or two coils exposed, sometimes in groups of two or three.



Fig. 3. a) Juvenile adder *Vipera berus* (~14 cm in length), recently emerged from hibernation, found under a refugia mat, 22 March 2012. b) Common lizards *Zootoca vivipara* (~13 cm), 17 August 2012.

Common lizards

Common lizards were the first reptiles to be seen appearing on 11 March, with both males and females present. Animals were seen sunning both on refugia mats and elsewhere throughout the survey period until the 7 August, usually observed at 9-10 am on sunny days (Fig. 3B). Upon disturbance, lizards would disappear, but usually returned to the same sunning position within 10-20 minutes.

DISCUSSION

Intensive monitoring at a site at Loch Lomond has revealed a rich population of reptiles, with significant numbers of adders, slow-worms and common lizards. These high numbers reflect the apparently ideal habitat, which closely corresponds to optimum habitat described where some large populations have been observed in the UK (Avery, 1962; Prestt, 1971; Stafford, 1987; Smith, 1990; Riddell, 1996; Platenberg and Griffiths, 1999; Beebee and Griffiths, 2000; Phelps, 2004a; Phelps 2004b). For adders the activity and breeding biology of the animals observed at Loch Lomond are consistent with behaviour seen elsewhere, but particularly that reported in northern parts of Europe or at higher altitudes (Viitanen, 1967; Neumeyer, 1987; Anderssen, 2003). Breeding behavior of slow-worms and common lizards, similar to that reported here, has been noted at other places in the UK (Avery, 1962; Smith, 1990; Riddell, 1996).

In a local context this population of reptiles is significant as anecdotal evidence from casual reports to CARG (CARG 2013) suggest that it is exceptional to observe all three species together in such numbers in the Clyde area. Thus the site needs to be protected and conserved. Populations of adders studied in the UK over long periods have demonstrated that not only can individual snakes live for over two or more decades, but also that they show strong attachment to their natal areas (Phelps 2004b). Thus, such sites require long-term protection to ensure the conservation of adder populations.

In future years I plan to continue to monitor this reptile population to examine how numbers fluctuate as the habitat potentially changes through succession. This is especially important as a small hydroelectric plant is planned for construction in 2014 that crosses the area shown in Fig. 1. The survey work described in this paper has formed the basis of an environmental mitigation plan for the construction work at the site, and so continued monitoring will be required to measure its success.

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Habitat preferences of European adders at Loch Lomond, Scotland

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ABSTRACT

An analysis of habitat types used by the European adder *Vipera berus* in the vicinity of Loch Lomond, Scotland is described. Three sites with different local geographies were chosen and studied, with hibernacula, mating and feeding areas mapped. Topography, fauna and flora were also monitored. Common features were identified between the sites, but striking differences were noted, emphasizing the flexibility in habitat requirement of this species. These observations suggest that adders could be far more widespread in Scotland than is currently recorded, and implies that their fragmentary distribution is controlled by other factors, such as human activities.

INTRODUCTION

The European adder is one of the mostly widely distributed reptiles in the world. Its breeding range extends across the Palearctic region from Britain in western Europe to north China and Sakalin in eastern Asia, with animals found north to above the Arctic Circle (Beebee and Griffiths, 2000).

The adder is one of the most investigated reptiles, with much known about its biology. Research, particularly in Europe, has revealed information about the annual breeding cycle and habitat requirements (Morrison, 1924; Viitanen, 1967; Prestt, 1971; Frazer, 1983; Neumeyer, 1987; Stafford, 1987; Beebee and Griffiths, 2000; Anderssen, 2003; Phelps, 2004a; Phelps, 2004b; McPhail, 2011; McNerny, 2013). Such studies have shown that populations of adders undergo regular behavioural patterns during the year. They hibernate through the winter in underground sites known as hibernacula, emerging in early spring to bask at sunning positions for a few weeks before undergoing ecdysis, as a prelude to courtship and mating (Fig. 1). Males and unmated females then move to adjacent wetter areas to feed, with gravid females remaining near hibernacula while incubating young, giving birth to live young in mid to late summer (Fig. 2). Animals return to hibernacula areas in late summer to bask, before entering hibernation in late autumn.

Studies have also identified habitat features used by adders (Prestt, 1971; Frazer, 1983; Neumeyer, 1987; Beebee and Griffiths, 2000; Anderssen, 2003; Phelps, 2004a; Phelps, 2004b; McNerny, 2013). Hibernation

sites are required that usually have a southerly aspect, which can be either on a slope or gully, but can also be on flat ground. Crucially, these wintering areas need to be well drained, and so free from flooding. Often they are covered with thicker vegetation, such as gorse *Ulex* spp or bramble *Rubus fruticosus*, and are usually associated with stands of bracken *Pteridium* spp. Adjacent habitats are often described as “complex” with areas of wet or marshy ground, and streams or ponds. These provide the range of areas which adders require to bask, to retreat to safety after disturbance, and to find food items.

Though adders are widely distributed in Scotland, found currently in all regions apart from Shetland, Orkney and the Outer Hebrides, their recorded distribution is fragmentary, and much reduced from that observed in the past (Harvie-Brown, 1887-1911; Arnold, 1995; Reading et al, 1996; Beebee and Griffiths, 2000). To understand why this might be I studied three populations near Loch Lomond which occurred at locations with very different local geographies. These studies revealed features common to all three sites, but also showed strong differences, which suggested that adders are adaptable and can inhabit a range of habitats. Hence, the fragmentary Scottish distribution is likely to be due not to limiting areas of suitable habitat, but instead results from other reasons, such as human influence.

METHODS

Three sites containing populations of adders were chosen for study near Loch Lomond, Scotland, as they show striking differences in local geography. The first is an upland moor, the second a lowland replanted native woodland, and the third a lowland golf course. The population of adders, along with other reptiles, at the lowland replanted native woodland, has been described (McNerny, 2013). The exact locations of these three sites are withheld to protect the reptile populations.



Fig. 1. Male adder *Vipera berus*, which had recently undergone ecdysis, searching for females to mate, 29 April 2013.

The sites were visually inspected from mid-February through to mid-October during 2011, 2012 and 2013, typically from 8 - 10 AM on sunny or warm days, the optimum time and conditions for finding adders; each site was visited a minimum of six times. Individuals were recognised through head patterns, which are unique and diagnostic (Benson, 1999; Sheldon and Bradley, 1989; Garbett, 2008; Sheldon and Bradley, 2011), and through repeated observations of individuals at particular sunning locations; this allowed numbers to be estimated. Hibernacula were identified where reptiles were noted on repeated occasions in early spring and late autumn. The locations of hibernacula, regular sunning positions, mating and feeding areas were mapped. Flora and fauna at each site, and the topography and geography, were also monitored.

RESULTS

Study site A

The site is an upland moor of predominantly heather *Calluna vulgaris*, at an altitude of 200 - 250 m, with a shallowly descending northerly aspect, on the south side of Loch Lomond. The moor, of c. 6 km², is surrounded by coniferous forestry plantations on three upper sides and sheep-grazed fields on the lower side, and is crossed by a burn through a gully of some 4 - 8 m in depth and up to 15 m in width, which empties in a northerly direction to Loch Lomond. The slopes of the gully are covered mostly in bracken, with small areas of gorse. The geology is a mixture of peat moorland and exposed granite rock.



Fig. 2. Juvenile adder *Vipera berus*, born, 4 August 2013.

The adder population consists of at least 22 individuals, with two hibernacula identified, where snakes were found in early spring and late autumn, on multiple occasions. One hibernaculum was found on a south-facing slope of the gully, which is covered in bracken and some gorse; here up to 14 adders were found emerging in early spring (Fig. 3a). Ecdysis, courting and mating were observed, with animals moving down into the burn, and across the moor, through the summer. The other

hibernaculum was found on a south facing rock outcrop on the moor, which is partially covered in heather and bracken (Fig. 3b); here at least eight adders were noted. At both hibernacula, common

lizards *Zootoca vivipara* were also detected, but no slow-worms *Anguis fragilis*.

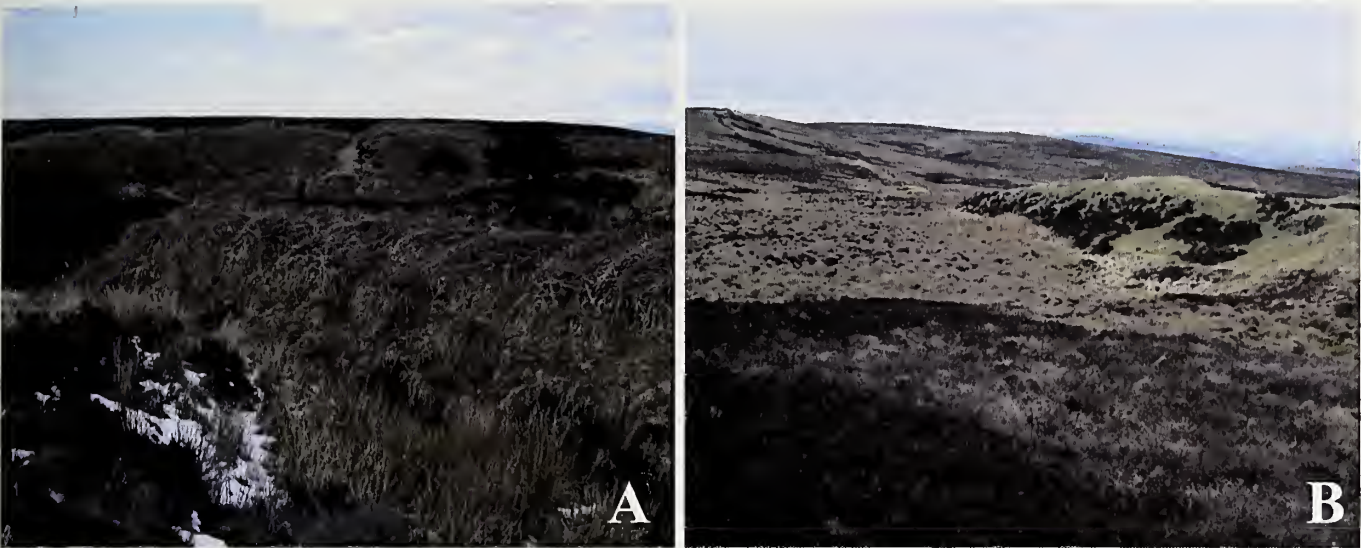


Fig. 3. Adder *Vipera berus* hibernacula on an upland moor at study site A. (a) South facing gully slope covered in bracken and some gorse. (b) South facing rock outcrop, with some heather and bracken.



Fig. 4. (a) Adder *Vipera berus* habitat on a lowland replanted native woodland at study site B. (b) & (c) Typical adder hibernacula on south facing slopes with bracken and gorse. (d) A more cryptic hibernaculum on flat ground, but with dense vegetation.

Study site B

The site is an area of south and west facing replanted native forest on the hills flanking the east shore of Loch Lomond, at an altitude of 40 - 90 m, of some 50 hectares (McInerny, 2013). The habitat consists of a mosaic of birch *Betula* spp. rowan *Sorbus* spp. and oak *Quercus* spp., interspersed with bracken, gorse, bramble, heather, and other native plants. The site is fenced, preventing the entry of deer, and is rich in native fauna and flora. It contains areas of exposed granite and mica schist rock, slopes and boggy areas, with a burn along its northern edge. The lower parts were once a sheep-farm (Fig. 4a). Many original dry stonewalls have collapsed, which have subsequently been overgrown by bracken, bramble and gorse; these piles of covered rocks have created hibernacula suitable for reptiles.

The adder population consists of at least 75 individuals. Over 22 hibernacula were identified, with each containing 1 - 3 snakes. The hibernacula occupy different locations, some being on south-facing slopes, with associated bracken and gorse (Fig. 4b and 4c). In other cases hibernacula are more cryptic, on flat ground, although they were always associated with denser vegetation (Fig. 4d). Ecdysis, courtship and mating were observed at the lower, flat parts of the site, with all snakes, apart from gravid females, moving during the summer period to wetter areas. This site also contains healthy populations of common lizards and slow-worms.

Study site C

The site is a golf course to the east of Loch Lomond on a south facing slope that rises from an altitude of 30 - 70 m, with a forestry plantation above, and a car road below. It contains large, managed areas of very short, cut grass on the greens and fairways, and areas of thicker grass, in the "rough". These managed areas are interspersed with large sections of bracken, gorse and bramble in which a number of small burns pass through (Fig. 5a). The geology is a mixture of glacial moraine and conglomerate rocks. A number of dry stonewalls pass through the site, and many dry stonewall bases have been created for golf tees.

The adder population consists of over 30 individuals. Hibernacula for adders and common lizards, which are also present, were found in dry stonewalls (Fig. 5b) and in conglomerate rock outcrops (Fig. 5c), and in areas of gorse. Ecdysis, courtship and mating were observed in the vicinity. Slow-worms were not found at this site.

The reptiles at this site benefit from the tolerance of the groundsmen, Club officials and players. Many have occasionally seen snakes and common lizards, but have chosen to co-exist with them, and indeed

enjoy seeing the reptiles on the course (groundsmen, Club Secretary, and numerous players, *pers. comm.*).

DISCUSSION

This study describes the examination of three populations of adders in different locations in the vicinity of Loch Lomond, to understand habitat features required for this species in Scotland. These studies have revealed that though adders can inhabit sites at different altitudes, local geography and flora, and varying degrees of human management, common features emerge. An important requirement is the availability of suitable locations for underground wintering in hibernacula. These were found to often be on south facing, well drained slopes, associated with bracken, bramble and gorse; occasionally they were found on flatter ground, where dry, subterranean holes were present. The flora appears to be important, with adders invariably associated with bracken, and usually found near bramble or gorse, which provide areas suitable for basking and retreat after disturbance. At all sites burns, along with wet, marshy ground, were found in the vicinity, which provide areas for snakes to move to in the summer when finding prey items. These features are similar to those observed at adder sites elsewhere in the U.K. and Europe (Prestt, 1971; Neumeyer, 1987; Beebee and Griffiths, 2000; Anderssen, 2003; Phelps, 2004a; Phelps, 2004b). Finally, but importantly, at all three sites near Loch Lomond, the adders avoided human persecution, either through remoteness (site A), protection (site B), or tolerance (site C).

The habitat features noted here used by adders are found in many places across Scotland that apparently do not have snakes (Arnold, 1995; *pers. obs.*), which leads to the question if and why they are absent in these places. In part this can be explained by the under-recording of reptiles across the country; adders, particularly, are difficult animals to locate. However, at the three sites described in this paper an important common feature is that adders are found where they avoid human interference. In each case it is for a different reason: remoteness of the moorland at site A, protection at the reserve at site B, and tolerance of the golfers at site C. But this observation can be generalised to help explain the distribution across Scotland as a whole (Beebee and Griffiths, 2000). Elsewhere, adders are found in nature reserves, on private land, on islands, and in remote, little visited areas. Where they are (rarely) found in proximity to humans, this is usually the result of local tolerance.

Further support for this premise is the observation that adders were in the past much more widely distributed across Scotland, being found in many

areas where they are now absent (Harvie-Brown, 1887-1911; Arnold, 1995; Reading et al, 1996; Beebee and Griffiths, 2000). This reduction in range is in part due to deliberate human persecution: there are recorded instances of adders being killed,

sometimes in large numbers, as they were considered pests (Service, 1902).

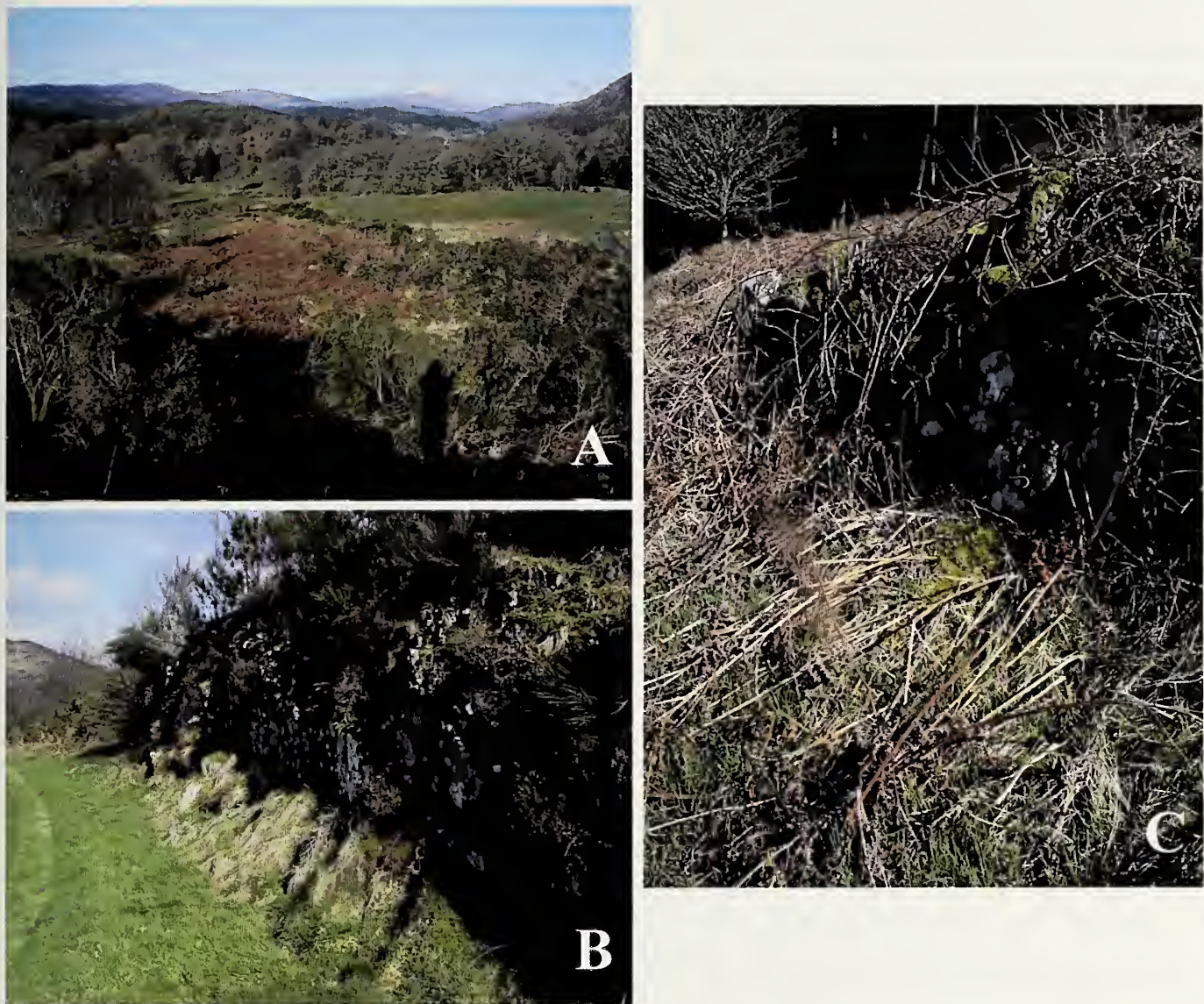


Fig. 5. (a) Adder *Vipera berus* habitat on a lowland golf course at study site C. (b) Adder hibernaculum on a south facing conglomerate rock outcrop. (c) Adder hibernaculum on a south facing dry stonewall.

The sites described in this paper illustrate that adders are extremely adaptable, being able to live in a range of different habitats, provided they have a few important features. That these features are found in many parts of Scotland raises the hope that with a more enlightened attitude by humans to snakes in the future, adders may again become more widespread.

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I would like to thank the landowners at two of the sites (B and C) for permission to monitor reptiles. Tribute should be paid to the tolerant attitude of the groundsmen, Club officials and players at the golf

course. Their exemplary understanding, treatment and behaviour to a poisonous snake illustrates how humans can co-exist with reptiles, to the benefit of both.

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An unusually high frequency of Atlantic salmon x brown trout hybrids in the Loch Lomond catchment, west-central Scotland.

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ABSTRACT

A genetic study to examine population structuring of fish identified by anglers on the basis of external morphology, as Atlantic salmon, *Salmo salar*, returning as sea-migrants to the Loch Lomond catchment, recorded a rate of hybridisation with brown trout, *Salmo trutta*, of 10.4%. This is much higher than previously reported for adult fish elsewhere and considerably higher than amongst juveniles sampled from across the catchment (0.7%). The sea-migrant hybrids recorded here were F_1 hybrids derived from matings comprising one brown trout female and at least three different salmon females. Mitochondrial DNA haplotypes suggest that these are associated with spawning in different parts of the Loch Lomond catchment. The cause(s) of the high incidence among adults is uncertain. However, these findings challenge the general view, derived from existing literature, that lifetime fitness in Atlantic salmon x brown trout hybrids is low. Suggesting that, at least occasionally, hybrid survival to sexual maturity may be similar to that of individuals in the parental populations. The potential impact of high hybrid survivorship on parental species dynamics is discussed.

KEYWORDS: hybrid survival; species integrity; *Salmo salar*; *Salmo trutta*.

INTRODUCTION

Despite that most commonly applied definitions of a species require (either explicitly or implicitly) operational reproductive barriers between species, (Mayden, 1997; Coyne & Orr, 2004), hybridisation between species of fish is relatively common (Hubbs, 1955; Chevassus, 1979; Verspoor & Hammar, 1991 and references therein).

In circumstances where reproductive isolating mechanisms in sympatric species are weak enough for hybridisation to occur, then a number of outcomes are possible. When hybridisation is frequent, and both survivorship and reproductive

competence of hybrids is high, then species can effectively merge (Taylor *et al.*, 2006) or a hybrid swarm may form (Benke, 1972). Alternatively, species may remain largely intact but introgression of genes from one species into the other may occur (Verspoor & Hammar, 1991). There have also been reported examples where a new fish taxon may have formed (see for example Sezaki *et al.*, 1994). All of these outcomes are dependent upon first generation (F_1) hybrids remaining viable (surviving and becoming reproductively competent) to reproduce, either with other hybrids, or one or both of the parent populations.

In natural systems, hybridisation is most likely to occur in closely related, recently diverged, species pairs with a common lineage (Verspoor & Hammar, 1991; Grant & Grant, 2005) presumably because the accumulation of isolating barriers is likely to be lower in such cases.

One pair of related species that share a common lineage diverging about 3.3 M years ago (Shedko *et al.* 2012) is the Atlantic salmon *Salmo salar* L. and the brown trout *Salmo trutta* L.. These species can, and do, hybridise naturally and commonly, in the wild (see Jordan *et al.*, 2007 & Makharov 2008 for reviews) and will also hybridise *in vitro* (Day, 1844; Garcia-Vazquez *et al.*, 2004) but there is evidence from the literature that in natural systems hybrid fitness may be impaired.

In the wild, hybrids of these species are frequently reported amongst the juvenile, freshwater stages of the life cycle. In 14 studies of 53 catchments where these species co-occur, hybrids have been found in 39 (Solomon & Child, 1978; Beland *et al.*, 1981; Crosier, 1984; Verspoor 1988; Garcia de Leaniz & Verspoor 1989; Hurrell and Price 1991; Jansson *et al.*, 1991, McGowan & Davidson, 1992; Jordan & Verspoor, 1993; Elo *et al.*, 1995; Hartley, 1996; Jansson & Ost, 1997; Matthews *et al.*, 2000; Garcia-Vazquez *et al.*, 2001).

The occurrence of Atlantic salmon x brown trout hybrids in the freshwater life stages in some catchments can be high. Verspoor (1988) for example, recorded hybridisation rates of up to 11.1% in parr (juvenile fish in their freshwater phase in their second year or older) in catchments in Newfoundland. In Sweden, 22.8% of parr in the River Gronan (Jansson *et al.*, 1991) and 66.7% in the River Dalalven, (Jansson & Ost, 1997) were hybrids. However, the reported incidence of hybrids at later life stages is significantly lower. Verspoor (1988) found 0.3% F_1 hybrids amongst Atlantic salmon smolts (the seaward migration phase of the life cycle) in 331 individuals, from 4 catchments in Newfoundland (the maximum occurrence was 1.75% in the River Trepassey). In England, only two F_1 hybrid smolts were identified from a large sample of salmon and trout smolts (the sea migration phase) from the River Piddle (Solomon & Child, 1978)

Amongst sea-migrant adult fish, Youngson *et al.*, (1992) recorded a single returning Atlantic salmon x brown trout hybrid, from the River Don, Scotland in a sample from the recreational fishery. Payne *et al.* (1972) examined a sample of 4431 adult apparent Atlantic salmon in commercial inshore fisheries around the UK and Ireland and found 0.4% of these fish were hybrids. In a sample of 198 returning sea-migrant adults from 3 rivers in Newfoundland rivers, Verspoor (1988) found no hybrids, despite that hybridisation had been recorded amongst parr sampled from these rivers.

Thus the pattern emerging from previous studies is that of a much lower frequency of Atlantic salmon x brown trout hybrids at later life stages, compared with earlier life stages, strongly suggestive of low hybrid survivorship and impaired long-term hybrid fitness.

During a study to examine population structuring of Atlantic salmon we had the opportunity to examine hybridisation frequencies between Atlantic salmon x brown trout amongst returning marine migrants and freshwater stages in a single Scottish catchment, Loch Lomond. These data we present here.

MATERIALS & METHODS

The study site

The Loch Lomond catchment, in west-central Scotland (56°07'N 004°38'W), comprises a large lake (Loch Lomond) with one major afferent tributary navigable by migratory salmonids (the Endrick Water), a number of minor afferent streams (the largest being the Rivers Fruin, Luss and Blane) and a single efferent river (the River Leven). Both Atlantic salmon and freshwater-resident (brown) and migratory (sea) forms of trout co-exist

naturally, occupying a similar range within the catchment.

Fry collection

Fry (age 0+), identified superficially as salmon, were collected by electrofishing in summer 2005, from 6 parts of the Lomond catchment known to support high densities of fish. A total of 281 fry were collected comprising: 70 from the lower Endrick Water (3 sites), 62 from the upper Endrick Water (3 sites), 37 from the Blane Water (2 sites), 41 from the River Luss, 33 from the River Fruin and 38 from the efferent River Leven (Fig.1).

Sea migrant collection

A sample of sea returning migrants showing the external characteristics of Atlantic salmon were collected from the rod fishery in 2006 from the Loch Lomond catchment. Fifteen individuals were collected from the fishery in the main loch, 31 from the fishery in efferent River Leven and 1 each from the rod fishery in the rivers Fruin and Endrick. The adipose fin was removed from captured fish and stored in 100% ethanol.

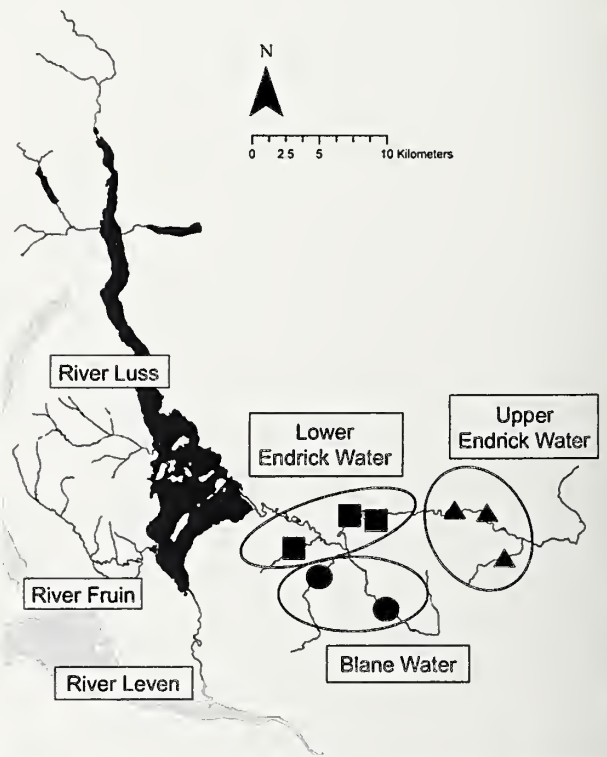


Fig. 1. The Loch Lomond catchment showing principal sampling areas; the lower Endrick Water (3 discrete sampling sites), the upper Endrick Water (3 discrete sampling sites), the Blane Water (2 discrete sampling sites), the River Luss, the River Fruin, the River Leven and Loch Lomond.

Genetic analysis

DNA was extracted from fin tissue from all individuals following the method of Knox *et al.* (2002). All samples were amplified at the diagnostic 5S rDNA locus to confirm the identity of

their species of origin using the procedure of Pendas et al., 1995. In addition, the ND1 region of the mtDNA was amplified by PCR (Youngson et al. 1992) and restricted with Hae III restriction enzyme which gives diagnostic fragment patterns for Atlantic salmon and brown trout (unpublished; Fig. 2). In addition mtDNA was amplified at the mitochondrial ND1 region and screened with five restriction enzymes for DNA sequence polymorphisms that are known to be common in Atlantic salmon from Europe (*AvaII*, *DraI*, *HaeIII*, *HinfI*, *RsaI*) (Knox et al., 2002).

RESULTS

Of the 281 juvenile, freshwater stage salmon collected in six spawning streams from across the Lomond catchment 0.7% (2 individuals) were found to be hybrids.

Table 1. The capture site, mass and sex of five Atlantic salmon x brown trout hybrids from the Loch Lomond catchment.

Sex	Capture site	Capture date	Mass (kg)
Female	Loch Lomond	08 July 2006	2.27
Female	River Leven	15 Aug 2006	2.49
Male	River Leven	30 June 2006	4.54
Male	River Leven	29 May 2006	6.12
Female	River Leven	27 May 2006	5.44

In contrast, 5 of the 48 (10.4%) sea migrant fish with externally salmon-like morphological characteristics were found to be Atlantic salmon x brown trout hybrids. Three of the sea-migrant hybrids were females and two were male fish. They comprised a broad size range (2.3 to 6.1 kg) strongly suggesting that they spanned multiple age classes. Four of the five were caught in the efferent River Leven and 1 in Loch Lomond itself.

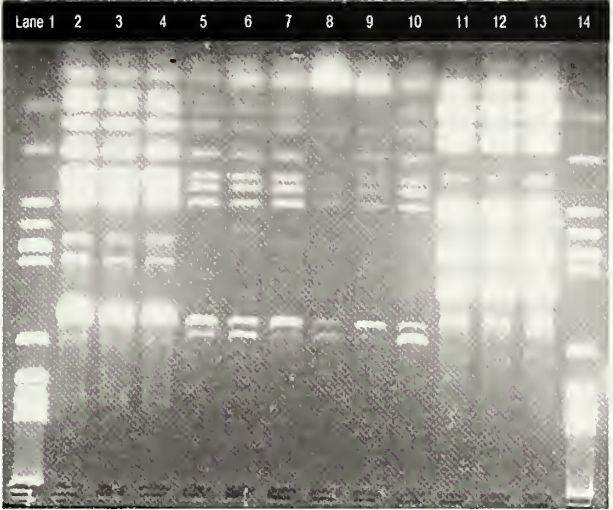


Fig. 2. The restriction fragment patterns obtained following digestion of the amplified ND1 gene with Hae III. Lanes 2 -10 - Atlantic salmon; brown trout lanes 11-13. Molecular size marker shown in the lanes 1 and 2 is phiX174 Hae III digest.

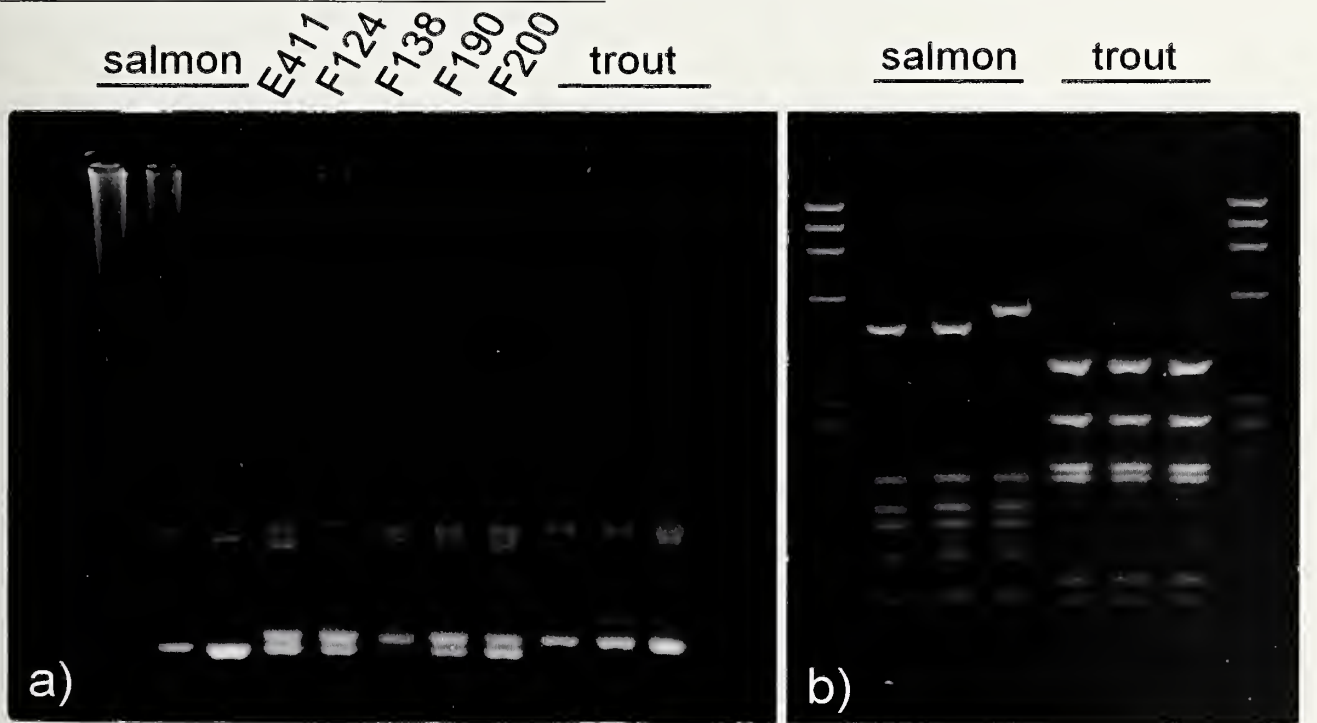


Fig. 3. Agar gel electropherograms showing patterns used to identify a) hybrids and pure salmon and trout based on 5sRNA assay and b) HaeIII ND1 assay; see text for details.

The direction of the hybridisation of the sea-migrants varied across fish in this study. Of the 5 hybrids, one (E411 in Fig. 3) had a trout female parent and the remaining 4 had salmon female parents. Of the 4 hybrids with salmon female parents, 3 distinct composite haplotypes were identified from restriction fragment length polymorphisms at the 5 mtDNA restriction sites in the ND1 region. Thus at least 3 different female salmon parents gave rise to the 4 hybrids with female salmon parents.

DISCUSSION

The incidence of sea-migrant hybrids found among adult "salmon" angled in the Leven system is significantly higher than has been reported for any other catchment where Atlantic salmon and brown trout co-exist (Payne *et al.*, 1972; Verspoor, 1988; Youngson *et al.*, 1992). It is also significantly higher than the frequency of hybrids observed for freshwater stage juveniles from the six salmon nursery areas in the catchment sampled, which represent the main known areas of salmon production.

In general the frequency of Atlantic salmon x brown trout hybrids reported in the literature is very low at later life stages compared with that of fry and parr (Solomon & Child, 1978; Beland *et al.*, 1981; Crosier, 1984; Verspoor, 1988; Garcia de Leaniz & Verspoor, 1989; Hurrell & Price, 1991; Jansson *et al.*, 1991; McGowan & Davidson, 1992; Jordan & Verspoor, 1993; Elo *et al.*, 1995; Hartley, 1996; Jansson & Ost, 1997; Matthews *et al.*, 2000; Garcia-Vazquez *et al.*, 2001). In most cases, where frequencies amongst juveniles and adults from the same river or region are compared, frequencies in the former are significantly lower. For example, in the study by Verspoor, (1988) in Newfoundland, parr hybrid frequency was significantly higher than the mature adult hybrid frequency ($\chi^2 = 6.2$, $P < 0.05$), both overall and when analysed on a river-specific basis. Indeed, no adult hybrids were found among the 196 adults screened. This strongly suggests that the fitness of hybrids in the wild is impaired. A study of survival of artificial crosses in semi-natural conditions also suggests that salmon x trout hybrids have reduced survivorship (Garcia-Vazquez *et al.*, 2002), with crosses having brown trout mothers showing particularly low survivorship. However, this situation does not appear to be the case under hatchery conditions, where survival is equal to that of parental types and no difference is seen for trout and salmon mothers (Chevassus 1979).

The returning adult sea-migrant Atlantic salmon x brown trout hybrids observed here are not the result of a single successful hybridisation event but the product of at least 4 separate pairings. There is some evidence of a bias in the direction of

hybridisation with four of the five pairings resulting from salmon female and trout male parentage. The hybrids also appear to derive from different locations in the catchment. Juvenile salmon in Loch Lomond show significant genetic structuring among sub-catchments, based on both mtDNA haplotype and microsatellite locus allele frequencies (Thompson & Verspoor, 2007). Of the four hybrids with salmon female parents, the observed mtDNA haplotypes suggest that the female parent of one originated from the afferent River Endrick, two from the efferent River Leven and one could have been from either the River Leven or the afferent Luss Water. Thus the observed hybrids do not appear to be the product of a single hybrid event and, on first impressions, to derive from a single part of the Leven catchment.

There are several possible explanations for the high incidence of salmon x trout hybrids observed among the adult "salmon" here. If the low survival rate of hybrids in Lomond are broadly similar to the survivorship of hybrids elsewhere (see e.g. Verspoor, 1988), then this suggests a very high frequency of hybrids amongst juveniles in the catchment. This was not found. However, the 0+ fry examined in this study (in 2005) did not comprise the same age cohort as the return sea-migrants in 2006. Thus for the observed pattern of sea-migrant hybrid frequency to occur, a much higher juvenile hybridisation rate must have occurred in the years before 2005. Alternatively, the observed frequencies may be an accurate reflection of earlier hybridisation rates in the parts of the catchments they came from but the hybrids derive from parts of the catchment not sampled in this study. These explanations are not mutually exclusive. It is very unlikely that there is a major part of the catchment that consistently supports a very large juvenile population of hybrids that was not sampled during this study. The evidence of studies from other catchments suggest that it would require a juvenile hybrid frequency (whether this was spatial or temporal) exceeding that reported before to achieve the hybridisation rate of 10% in adult fish observed here (see Payne *et al.*, 1972; Verspoor, 1988; Youngson *et al.*, 1992). Given that the hybrids represented 10% of the catch, it suggests that a part of the catchment producing much more than 10% of the production of adult fish in the system has been missed.

One possible explanation is that the incidence of hybrids in the system was elevated due to the increased incidence of escaped farm "salmon" in the system, as was reported in 2006 (Anon 2006). Most simply, the majority of the hybrids observed could be escapes from a farm. Though hybrids are not normally used, they have been inadvertently produced on some farms due to misidentification of sea trout as salmon when broodstock are collected

(EV, unpublished data). Alternatively, it is known that the incidence of hybrids increases where farm escapes are present (Youngson *et al.* 1993; Hindar and Balstad 1994; Matthews *et al.* 2000). 2006 is not the only year that farm escapes have been reported in the system. They were reported in 1998 as well (Anon 2006) and conceivably may also have been present in the years 2000-2003, when the hybrid adults would have been spawned. If so, then it may be that there have also been other spikes in the frequency of hybrids in the system prior to and after this date (from spawning of farm salmon in 2006) that have not been recorded. Alternatively, these hybrids may comprise fish released as a part of a stock enhancement programme where trout and salmon were accidentally or deliberately crossed. Large sea-run sea-trout and salmon can occasionally be confused with each other and there was a stocking programme in operation at this time. Thus this possibility cannot be ruled out.

Another potential explanation is that the survivorship of hybrids from the Lomond catchment is unusually high, at least in the years prior to 2006 and significantly greater than reported elsewhere. However, there have been no studies that have attempted to identify sources of mortality in salmon x trout hybrids and the fundamental mechanisms underlying hybrid fitness remain unknown. However, if increased hybrid survival is important it is likely that some element of environmental change or reduced abundance of salmon and trout in the system seem the most likely candidate.

Increased hybridisation does not mean that the species integrity of Atlantic salmon and brown trout is at risk. Although sexually mature viable hybrids have been produced *in vitro*, (Jones, 1947) and hybrid backcrosses with Atlantic salmon have been recorded under experimental conditions (Garcia-Vazquez *et al.*, 2003). The two species differ in their chromosome number (Philips & Rab 2001). In Europe, the Atlantic salmon normally has 29 pairs of chromosomes (2N=58) with 74 chromosome arms (NF) while brown trout in western Europe appear to most typically have 42 chromosome pairs and 102 arms (e.g. Garcia-Vasquez *et al.*, 1995). The maintenance of chromosomal function in hybrids despite these differences suggests that pairing of brown trout chromosomes with corresponding chromosomal regions on salmon chromosomes during mitosis is possible, allowing a stable and full gene complement to be inherited by most somatic cells. However, this stability appears to breakdown in subsequent generations, due to mitotic and meiotic disturbances associated with imbalanced chromosome sets, and mixing of different co-adapted gene complexes (e.g. Cauwelier *et al.* 2012) and probably underlies the failure of most

backcross and F_2 individuals to survive. However, natural triploid female hybrids have been observed and can produce diploid eggs which can be successfully fertilised by males of the parental species (Makharov 2008). A recent study of single nucleotide polymorphism variation in the River Tweed, S.E. Scotland has found some evidence for natural backcrosses (EV, unpublished) and there is also circumstantial evidence suggesting that introgression may have occurred in some circumstances in the past. However, a conclusive case for hybridisation commonly leading to introgression between these species is lacking.

Overall, the available evidence would suggest that a direct genetic impact of increased hybridisation on either the trout or salmon population from the Lomond catchment is unlikely. However, an indirect ecological impact through competitive interactions cannot be ruled out, based on empirical and modelling evidence of interactions between stocked or farmed fish and native fish in the wild (McGinnity *et al.*, 2003, 2009). The presence of Atlantic salmon x brown trout hybrids may well have similar negative impacts on the wild parental populations at some stages of the lifecycle, beyond the loss of production associated with the hybridisation itself, if hybrids are particularly abundant and survivorship is high. Thus factors which increase hybridisation rates, such as increased levels of farm escapes or depressed abundance of one or both parental populations, may add to an already large list of factors threatening the abundance of salmon and trout in Scotland.

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Nocturnal Ichneumonoidea (Hymenoptera) caught by the Rothamsted light trap at Rowardennan, Loch Lomondside

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INTRODUCTION

Since 1968 the Rothamsted Insect Survey (RIS) has operated a network of specially designed light-traps throughout the UK and the data obtained from them have been used to monitor the long term population trends of the most common and widespread British moths (Fox *et al.*, 2006). A trap located at the Scottish Centre for Ecology and Natural Environment (formerly known as the Glasgow University Field Station) has been operated continuously since 1968 and has added greatly to knowledge of the moth assemblage on east Loch Lomondside (Salama *et al.*, 2007; Knowler and Gregory, 2008; Knowler, 2010). In addition to moths, light traps catch representatives of many other insect Orders and, during the years that the Rowardennan trap has been run, some of these have been collected and sent to relevant experts for identification. This paper presents an analysis of 2373 Ichneumonoidea recovered from the catch of the Rowardennan trap during 2004 and 2010.

METHODS

A standard Rothamsted light trap with a 200W tungsten filament is located at NS378960 in an extensive belt of semi-natural oak woods which covers much of the lower slopes of both the eastern and western shores of Loch Lomond. It comprises mostly *Quercus petraea* x *robor* hybrids. Other micro-habitats close to the trap are smaller quantities of alder (*Alnus glutosa*) and sallow (*Salix* sp.) that fringe the shore of Loch Lomond and the nearby Dubh Lochan. The area also contains patches of planted conifers and the upper loch-side slopes are characterised by more open habitats and birch (*Betula* sp.) wood.

The trap is operated by volunteers who until 2008 sent the catch to RIS staff to identify the macro moths. Since 2009 moth identification has been undertaken by the first author and this has given him access to the other insects caught by the trap.

From 7th May to 31st December 2004, Phil Gould, formerly of the Rothamsted light trap survey, separated Ichneumonoidea from the catch of the

Rowardennan trap and sent them to the second author to identify. Information on the precise dates of capture of these insects was not retained as the insects were sent in a bulk sample. However, for the whole of 2010, J.T.K. separated the Ichneumonoidea from each day/weekend catch and separately packaged and dated them before sending them to G.R.B. for identification.

G.R.B. runs a recording scheme for nocturnal Ichneumonoidea (<http://www.nhm.ac.uk/research-curation/about-science/staff-directory/life-sciences/g-broad/index.html>) and the catches from the Rothamsted light trap network have proved particularly useful for their wide geographical coverage. Many of the ichneumonoid species recorded from the Rowardennan trap are typical of nocturnal species in that they are pale orange/testaceous with long antennae and large eyes, a morphology that has convergently evolved in several subfamilies of the two ichneumonoid families (Braconidae and Ichneumonidae) but which is particularly characteristic of the ichneumonid subfamily Ophioninae. These obviously nocturnal species can be identified using G.R.B.'s draft keys (<http://www.nhm.ac.uk/research-curation/about-science/staff-directory/life-sciences/g-broad/index.html>) and through several other sources (e.g. van Achterberg, 1979, 1984, 1992; Brock, 1982; Shaw, 2010). A few specimens of the species-rich and difficult braconid genus, *Aleiodes*, were identified by Dr Mark Shaw (Edinburgh) and some *Lissonota* (Ichneumonidae: Banchinae) were identified by Dr Jim Brock (Ely). Many other ichneumonoids (and other Hymenoptera) can be found at light traps. Many of these are not obviously nocturnal and were identified using a large body of literature and by comparison with specimens in the collections of the Natural History Museum. Vouchers of all species have been deposited in the Natural History Museum.

Table 1 shows the total nocturnal Ichneumonoidea identified from the catch of the Rothamsted trap at Rowardennan.

Table 1. Ichneumonoidea identified in the catch of the Rowardennan Light Trap 2004 and 2010.

Species	Family	Subfamily	Total collected	Earliest and latest dates
<i>Charmon cruentatus</i> Haliday	Braconidae	Charmontinae	1 female	2004
<i>Macrocentrus nitidus</i> (Wesmael)	Braconidae	Charmontinae	1 female	02/09
<i>Ascogaster consobrina</i> (Curtis)	Braconidae	Cheloninae	2 male	16/06
<i>Pygostolus otiorhynchi</i> (Boudier)	Braconidae	Euphorinae	2 female	16/08-26/08
<i>Pygostolus sticticus</i> (Fabricius)	Braconidae	Euphorinae	25 female	15/06-12/08
<i>Syntretus idalius</i> (Haliday)	Braconidae	Euphorinae	1 male	17/06
<i>Syntretus xanthocephalus</i> (Marshall)	Braconidae	Euphorinae	1 female	20/08
<i>Homolobus flagitator</i> (Curtis)	Braconidae	Homolobinae	118 female, 34 male	16/06-10/10
<i>Homolobus infumator</i> (Lyle)	Braconidae	Homolobinae	14 female	06/09-13/10
<i>Macrocentrus nidulator</i> (Nees)	Braconidae	Macrocentrinae	1 female	06/10
<i>Macrocentrus nitidus</i> (Wesmael)	Braconidae	Macrocentrinae	1 female	09/10
<i>Meteorus pendulus</i> (Müller)	Braconidae	Meteorinae	1 female	2004
<i>Zele albiditarsus</i> Curtis	Braconidae	Meteorinae	9 female, 2 male	25/06-17/10
<i>Zele chlorophthalmus</i> (Spinola)	Braconidae	Meteorinae	1 female	17/08
<i>Zele deceptor</i> (Wesmael)	Braconidae	Meteorinae	65 female, 1 male	25/05-07/10
<i>Aleiodes nigriceps</i> (Wesmael)	Braconidae	Rogadinae	1 male	2004
<i>Aleiodes nigricomis</i> (Wesmael)	Braconidae	Rogadinae	2 female, 1 male	07/10-08/10
<i>Aleiodes pictus</i> agg.	Braconidae	Rogadinae	1 male	2004
<i>Heterogamus dispar</i> (Haliday)	Braconidae	Rogadinae	7 female, 2 male	29/07-20/08
<i>Agrypon flaveolatum</i> (Gravenhorst)	Ichneumonidae	Anomaloninae	13 female	2004
<i>Lissonota biguttata</i> (Holmgren)	Ichneumonidae	Banchinae	2 female	30/06-21/07
<i>Lissonota tenerrima</i> (Thomson)	Ichneumonidae	Banchinae	1 female	27/08
<i>Gelis albipalpus</i> (Thomson)	Ichneumonidae	Cryptinae	1 female	20/08
<i>Gnotus macrurus</i> (Thomson)	Ichneumonidae	Cryptinae	1 female	2004
<i>Orthizema triannulatum</i> (Thomson)	Ichneumonidae	Cryptinae	1 female	26/07

<i>Absyrtus vicinator</i> (Thunberg)	Ichneumonidae	Ctenopelmatinae	9 female, 11 male	09/07-07/10
<i>Alexeter nebulator</i> (Thunberg)	Ichneumonidae	Ctenopelmatinae	2 female	20/08-29/09
<i>Hadrodactylus idari</i> (Kasparyan & Shaw)	Ichneumonidae	Ctenopelmatinae	1 female	06/06
<i>Himerta sepulchralis</i> (Holmgren)	Ichneumonidae	Ctenopelmatinae	2 female, 2 male	10/09-13/09
<i>Opheltes glaucopterus</i> (Linnaeus)	Ichneumonidae	Ctenopelmatinae	2 females	2004
<i>Perilissus ?pallidus</i> (Gravenhorst)	Ichneumonidae	Ctenopelmatinae	17 female, 1 male	2004
<i>Allomacrus arcticus</i> (Holmgren)	Ichneumonidae	Cylloceriinae	16 female	25/06-02/07
<i>Sussaba cognata</i> (Holmgren)	Ichneumonidae	Diplazontinae	1 female	29/09
<i>Woldstedtius</i> sp.	Ichneumonidae	Diplazontinae	1 female	2004
<i>Euceros serricornis</i> (Haliday)	Ichneumonidae	Eucerotinae	1 male	2004
<i>Achais oratorius</i> (Fabricius)	Ichneumonidae	Ichneumoninae	1 female	20/09
<i>Aoplus ochropis</i> (Gmelin)	Ichneumonidae	Ichneumoninae	1 female	20-Aug
<i>Astiphromma granigerum</i> (Thomson)	Ichneumonidae	Mesochorinae	1 female, 2 male	09/09
<i>Astiphromma splenium</i> (Curtis)	Ichneumonidae	Mesochorinae	3 female, 1 male	07/05-13/09
<i>Cidaphus areolatus</i> (Boie)	Ichneumonidae	Mesochorinae	10 female, 1 male	22/07-29/09
<i>Cidaphus atricillus</i> (Haliday)	Ichneumonidae	Mesochorinae	2 female	18/08
<i>Enicospilus adustus</i> (Haller)	Ichneumonidae	Ophioninae	1 female	2004
<i>Enicospilus ramidulus</i> (Linnaeus)	Ichneumonidae	Ophioninae	2 female	16/09 – 19/09
<i>Ophion ?pteridis</i> (Kriechbaumer)	Ichneumonidae	Ophioninae	1 female	08/09
<i>Ophion brevicornis</i> (Morley)	Ichneumonidae	Ophioninae	1 male	23/06
<i>Ophion costatus</i> (Ratzeburg)	Ichneumonidae	Ophioninae	21 female, 41 male	18/05-30/06
<i>Ophion crassicornis</i> (Brock)	Ichneumonidae	Ophioninae	1 female, 3 male	04/06-23/06
<i>Ophion minutus</i> (Kriechbaumer)	Ichneumonidae	Ophioninae	15 female, 2 male	05/05-17/06
<i>Ophion mocsaryi</i> (Brauns)	Ichneumonidae	Ophioninae	13 female, 1 male	28/05-11/07
<i>Ophion obscuratus</i> (Fabricius)	Ichneumonidae	Ophioninae	7 female, 4 male	18/04-08/06
<i>Ophion ocellaris</i> (Ulbricht)	Ichneumonidae	Ophioninae	3 female, 1 male	07/05-21/07
<i>Ophion parvulus</i> (Kriechbaumer)	Ichneumonidae	Ophioninae	19 female, 3 male	04/06-06/10
<i>Ophion scutellaris</i> (Thomson)	Ichneumonidae	Ophioninae	3 female	12/04-02/05
<i>Ophion ventricosus</i> (Gravenhorst)	Ichneumonidae	Ophioninae	11 female	04/06-17/06

<i>Megastylus cruentator</i> (Schjødte)	Ichneumonidae	Orthocentrinae	1 female	15/11
<i>Megastylus pectoralis</i> (Förster)	Ichneumonidae	Orthocentrinae	5 female	16/09-25/10
<i>Plectiscus impurator</i> (Gravenhorst)	Ichneumonidae	Orthocentrinae	8 female, 6 male	09/09-06/10
<i>Symplecis bicingulata</i> (Gravenhorst)	Ichneumonidae	Orthocentrinae	1 male	21/09
<i>Oxytorus armatus</i> (Thomson)	Ichneumonidae	Oxytorinae	4 male	28/07-15/08
<i>Oxytorus luridator</i> (Gravenhorst)	Ichneumonidae	Oxytorinae	5 Male	01/07-26/07
<i>Acrodactyla degener</i> (Haliday)	Ichneumonidae	Pimplinae	1 female	20/08
<i>Pimpla flavicoxis</i> (Thomson)	Ichneumonidae	Pimplinae	6 female, 3 male	16/07-10/10
<i>Pimpla insignatoria</i> (Gravenhorst)	Ichneumonidae	Pimplinae	1 female	22/10
<i>Scambus inanis</i> (Schrank)	Ichneumonidae	Pimplinae	1 male	20/08
<i>Schizopyga frigida</i> (Cresson)	Ichneumonidae	Pimplinae	2 female	01/10-10/10
<i>Dyspetes luteomarginatus</i> (Habermehl)	Ichneumonidae	Tryphoninae	1 male	03/09
<i>Hercus fontinalis</i> (Holmgren)	Ichneumonidae	Tryphoninae	5 female, 4 male	25/06-14/09
<i>Netelia ?fuscicarpus</i> (Kokujev)	Ichneumonidae	Tryphoninae	2 female	2004
<i>Netelia ?ocellaris</i> (Thomson)	Ichneumonidae	Tryphoninae	2 female	2004
<i>Netelia cristata</i> (Thomson)	Ichneumonidae	Tryphoninae	131 female, 41 male	01/05-13/10
<i>Netelia fulvator</i> Delrio	Ichneumonidae	Tryphoninae	1 male	10/08
<i>Netelia inedita</i> (Kokujev)	Ichneumonidae	Tryphoninae	1 female	2004
<i>Netelia infractor</i> Delrio	Ichneumonidae	Tryphoninae	1 male	09/09
<i>Netelia latungula</i> (Thomson)	Ichneumonidae	Tryphoninae	25 female, 13 male	07/05-25/06
<i>Netelia pallens</i> (Schmiedeknecht)	Ichneumonidae	Tryphoninae	3 female, 14 male	04/06-14/10
<i>Netelia tarsata</i> (Brischke)	Ichneumonidae	Tryphoninae	477 female, 79 male	07/05-13/10
<i>Netelia virgata</i> (Geoffroy)	Ichneumonidae	Tryphoninae	658 female, 179 male	21/05-01/11
<i>Oedemopsis scabricula</i> (Gravenhorst)	Ichneumonidae	Tryphoninae	21 females, 19 males	30/06-22/08
<i>Polyblastus melanostigmus</i> (Holmgren)	Ichneumonidae	Tryphoninae	1 male	2004
<i>Polyblastus wahlbergi</i> (Holmgren)	Ichneumonidae	Tryphoninae	1 male	2004
<i>Thymaritis tener</i> (Gravenhorst)	Ichneumonidae	Tryphoninae	1 male	14/09
<i>Ischnoceros caligatus</i> (Gravenhorst)	Ichneumonidae	Xoridinae	1 female	14/09

RESULTS & DISCUSSION

Those insects caught in 2004 can only be identified as having been caught between 7th May (when ichneumonoids started to be separated from the rest of the catch) and the end of the year. Those caught in 2010 were known to be caught on a precise day, over a three day weekend or a four day Bank holiday.

Based on G.R.B.'s experience of the British fauna, many of the recorded Ichneumonoidea are widespread and common. Distribution and abundance data are mostly lacking for parasitoid Hymenoptera, although several publications by Mark Shaw and co-workers have started to assess the abundance of some ichneumonoids on the basis of numbers of specimens in the collections of the National Museums of Scotland, mostly assembled by Mark Shaw and often reared from known hosts (Schwarz & Shaw 1998, 1999; Shaw, 2010). We can be fairly certain that some of the more recognisable species, such as *Cidaphus areolatus* and *Euceros serricornis*, have genuinely restricted ranges and are rarely encountered. Rowardennan is one of very few sites in Britain where *C. areolatus* is known to occur, despite the fact it is nocturnal and readily comes to light. *Gnotus macrurus* is very poorly known and this is the only recent British specimen known to us. The numbers of *Netelia* species trapped at Rowardennan are unusually high compared to other light traps for which there is a good data series. *Netelia* are all, where known, koinobiont ectoparasitoids of Lepidoptera larvae (that is, the parasitoid egg is attached externally on the host, which continues its development normally until it is overwhelmed by the *Netelia* larva after the caterpillar has prepared its pupation retreat). Although the taxonomy and host relations of *Netelia* species have been much confused in the literature, G.R.B. and Mark Shaw are completing a paper revising the British species and we can confidently describe the broader patterns of host ranges for many of our species. Whilst *Netelia* were, on the whole, abundant in the samples, some species, such as *N. infractor*, that mainly attack noctuid or notodontid hosts, were very uncommonly caught relative to some other sites. Also noteworthy was the capture of a single male *Netelia* specimen that represents an undescribed species (Broad & Shaw, in prep.).

It is noteworthy that many species of Ichneumonoidea were consistently recorded over a protracted period of up to nearly six months. In the case of *Netelia tarsata* and *Netelia cristata* their abundance rose to a peak over a prolonged period of weeks and then fell off, again over several weeks (fig1). These species are plurivoltine (the exact number of generations is impossible to ascertain) but build up to a peak population late in the season. Many species however, show no discernible pattern

in abundance but have a protracted flight season. Thus, the 153 *Homolobus flagitator* that were recorded between 16th June and 10th October showed no evidence of a peak flight period, being recorded in ones, twos and threes on many days throughout the period. Similarly the 66 *Zeledceptor* were caught regularly in small numbers between 25th May and 7th October. It is unsurprising that plurivoltine parasitoids were much more numerous than univoltine species, such as most of the *Ophion* species. The host ranges of these plurivoltine species tend to be fairly broad (e.g. van Achterberg, 1979, 1984; Shaw, 2010) and the prolonged flight time indicates that on Loch Lomondside they use multiple hosts over several months. *Netelia cristata* has a very broad host range, utilising host caterpillars of several different families, in different feeding niches (Broad & Shaw, in prep.). All of the most abundant ichneumonoids in these samples are parasitoids of Geometridae, although none are host specialists. The most abundant species, *Netelia tarsata* and *N. virgata*, have host ranges centred on, respectively, pug larvae (Geometridae: Larentiinae: Eupitheciini) and *Hydriomena* species (Geometridae: Larentiinae) (Broad & Shaw, in prep.). July highflyer (*Hydriomena furcata*) is common, sometimes abundant, on Loch Lomondside, and is also one of the hosts of *Homolobus flagitator* (Shaw, 2010), which was caught in much greater number than in other Rothamsted light trap samples that have been examined by the second author. Other moths that serve as hosts for several of the commonly collected ichneumonoids, and which can be very common at the site, include mottled umber (*Erannis defoliaria*), the November moths (*Epirrita* spp.) and spring usher (*Agriopis leucophaearia*) (Knowler, 2010).

The above geometrid moth species show considerable year to year variation in their abundance on Loch Lomondside (Knowler, 2010). Given the large numbers of parasitoids that use these species and can be readily sampled in a light trap, the Rowardennan site could prove fruitful for investigators wishing to model the interactions of non-host-specific parasitoid species in relation to cyclical population dynamics of their hosts.

Some parasitoids collected in the Rowardennan trap in good numbers are more characteristic of southern woodlands, e.g. *Ophion costatus* and *O. ventricosus*. Their presence in Loch Lomondside but absence from much of the rest of Scotland is probably testament to the loss of much of the old, oak-dominated woodland.

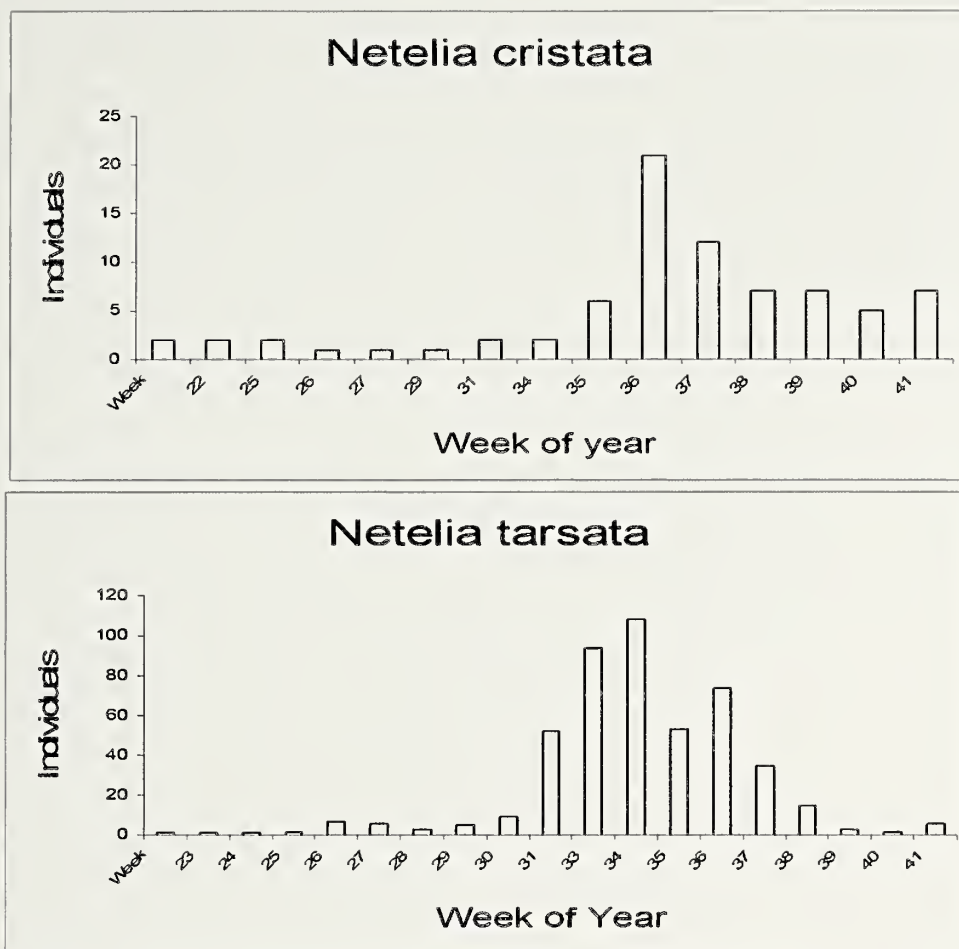


Fig.1. Numbers of *Netelia cristata* and *Netelia tarsata* trapped in 2010.

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Recent observations of “mystery star jelly” in Scotland appear to confirm one origin as spawn jelly from frogs or toads

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Stories of strange jelly deposits in the countryside have a long history going as far back as the Middle Ages (McKenny Hughes, 1910). An association between jelly and shooting stars seems to have become widespread, even appearing in popular literature such as Walter Scott's "The Talisman". The jelly has been known by different names such as star jelly, star gelly, star shot, star shoot, star slough, star fall'n, or pwdre ser (Welsh: rot of the stars). However, even in the Middle Ages more enlightened investigators considered that the jelly may derive from frog viscera discarded by predators. Baylis (1926) examined star jelly samples collected from Dartmoor and in one case the jelly was accompanied by oviducts and ovaries with black eggs along with remnants of an alimentary tract and bladder of a frog or toad. This seemed to confirm the theory that jelly deposits originated from predation on frogs or toads. Baylis (1926) pointed to weasels, stoats, badgers, crows, or buzzards as likely suspects. In their guide to animal tracks and signs, Bang & Dahlstrom (1972) show a photograph of similar jelly deposits which they attributed to frog oviducts discarded by buzzards.

In the past few years, the occurrences of masses of translucent jelly-like material deposited in gardens, parks and hillsides throughout Scotland have generated a lot of interest among walkers, ramblers, and naturalists. A BBC Radio Scotland "Out of Doors" programme in 2008 highlighted the 'mystery' and urged listeners to send in details of any sightings to their webpage and comment on what they thought the jelly might be.

The webpage (<http://www.bbc.co.uk/scotland/outdoors/articles/jelly/>) received over 350 postings from October 2008 to February 2009 with 132 sightings of star jelly from Britain (including 47 from Scotland) as well as some sightings from other parts of the world. The sightings occurred through all seasons of the year. Nine of the British sightings referred to deposits of black globules, resembling fish roe or caviar, associated with the jelly, which supports the frog spawn theory. Around a dozen photos of star jelly were submitted to the website gallery including one

from Moffat in October 2008 where the jelly mass was accompanied by a mound of black eggs. Another photo showed two large slugs (*Arion ater*) mating and producing a sizeable globule of jelly in the process that may explain some jelly cases. One anecdotal account from Cumbria claimed the jelly resulted from frogs being eaten by buzzards and a similar account, from Sweden, cited marsh harriers as the culprits, skinning and dismembering toads. Many respondents also suggested herons may regurgitate spawn jelly from frogs as it swells up after they have been swallowed. Additional suggestions for the source of the jelly included blue-green algae (Cyanobacteria), bryozoans, diatoms ('rock snot'), tree sap, slime mould, stag (or sheep) semen, deer phlegm, sheep afterbirth, slug slime, fish/eel slime, or otter anal jelly/spraint. Most of the ideas lacked any supporting evidence and some others were wildly speculative such as jellyfish, nappy jelly, garden silica gel, aircraft toilet discharge, drilling polymer, chemical sprays, or silica from meteorites.



Fig. 1. Egg mass collected near Cochno Loch, 2007.

Following the BBC programme star jelly samples were collected in 2009 and examined by Hans Sluiman, an algae expert at the Royal Botanic Gardens in Edinburgh, and DNA testing was undertaken by Andy Taylor, a mycologist at the Macauley Institute in Aberdeen. The jelly samples had no obvious cellular structure but proved to be

contaminated by fungal and bacterial growth and the DNA results were inconclusive.



Fig. 2. Star jelly and eggs, collected in the Menteith Hills 2008.

The star jelly ‘mystery’ was taken up by the popular press with short articles appearing in *The Times* (Reid 2009, Simons 2009, <http://www.thetimes.co.uk>) though these added little in the way of scientific explanation. Following this the Open University’s iSpot website (<http://www.ispot.org.uk/node/101544>), where nature watchers share their observations, claimed to have solved the mystery with a series of photos taken in the Mendips in February 2010. They showed various lumps of jelly strewn on grass including jelly globules dotted with black eggs (similar to laid frog spawn), jelly globules without eggs, and separate masses of black eggs all clearly originating from a frog. The website also showed a number of photos of crystal brain fungus (*Exidia nucleata*) that forms similar jelly masses on rotting wood. At least one of the ‘crystal brain’ photos is of jelly on grass and is likely to be star jelly.



Fig. 3. Star jelly, collected in the Ochil Hills, 2010.

The purpose of this note is to add a little more evidence to the discussion based on some recent direct observations of star jelly in Scotland and

hopefully dispel some of the myths about the phenomenon. A couple of these records originally appeared on a blog webpage (<http://fredandsarah.blogspot.com/search/label/star%20jelly>) set up by one of us (Sarah Longrigg) but are repeated here to bring them to a wider audience. The other two findings were by SEPA scientists Nicole Ross and Myles O’Reilly:

1. Kilpatrick Hills, Cochno Loch (NGR NS 490 764), observed by Sarah Longrigg, 28 March 2007. A small deposit, a couple of centimetres diameter, comprising around 100 black eggs (but no jelly) lying on dead grassy vegetation (Fig. 1).

2. Menteith Hills, Lochan Allt a’ Chip Dhuibh (NGR NN 571 040), observed by Sarah Longrigg, 28 March 2009. A deposit of whitish coiled jelly around 3 cm in diameter accompanied by a small mass of about 100 black eggs. A second small deposit of black eggs was present a few centimetres away (Fig. 2).

3. Ochil Hills, Warroch West Burn, 5 km NW of Dalqueich (NGR NO 04266 05822), observed by Nicole Ross and Nikki Broad, 20 Sept. 2011. The jelly was found on grass about 50 m away from the burn on a rough sheer-sided (sheep) path. A SEPA survey ecologist, Nikki Broad, discovered the jelly accidentally by putting her hand in it while scrambling up the path. The jelly consisted of an oval mass just a few centimetres long. The coloration was whitish, but partially translucent (Fig. 3).

4. Glasgow, Rouken Glen Park (NGR NS 54790 58370), observed by Myles O’Reilly, 9 Oct. 2011. The jelly was found on a grassy area (close to the walled garden) and not far from the Auldhouse Burn river. There were three masses of whitish and semi-transparent jelly with a total volume of around 120 ml (Fig. 4a-d). Lying adjacent to the jelly was a small deposit, volume around 5 ml, of decaying black eggs. Samples of the jelly and the eggs were collected for DNA analysis at the University of Glasgow. Unfortunately the DNA results proved inconclusive as the jelly and the eggs were contaminated by bacteria. However, microscopical examination of the eggs indicated they were consistent with ova and ovary remnants of frogs or toads. The eggs have a darkly pigmented hemisphere and a paler hemisphere which is characteristic of the common frog (Fig. 4e-f).

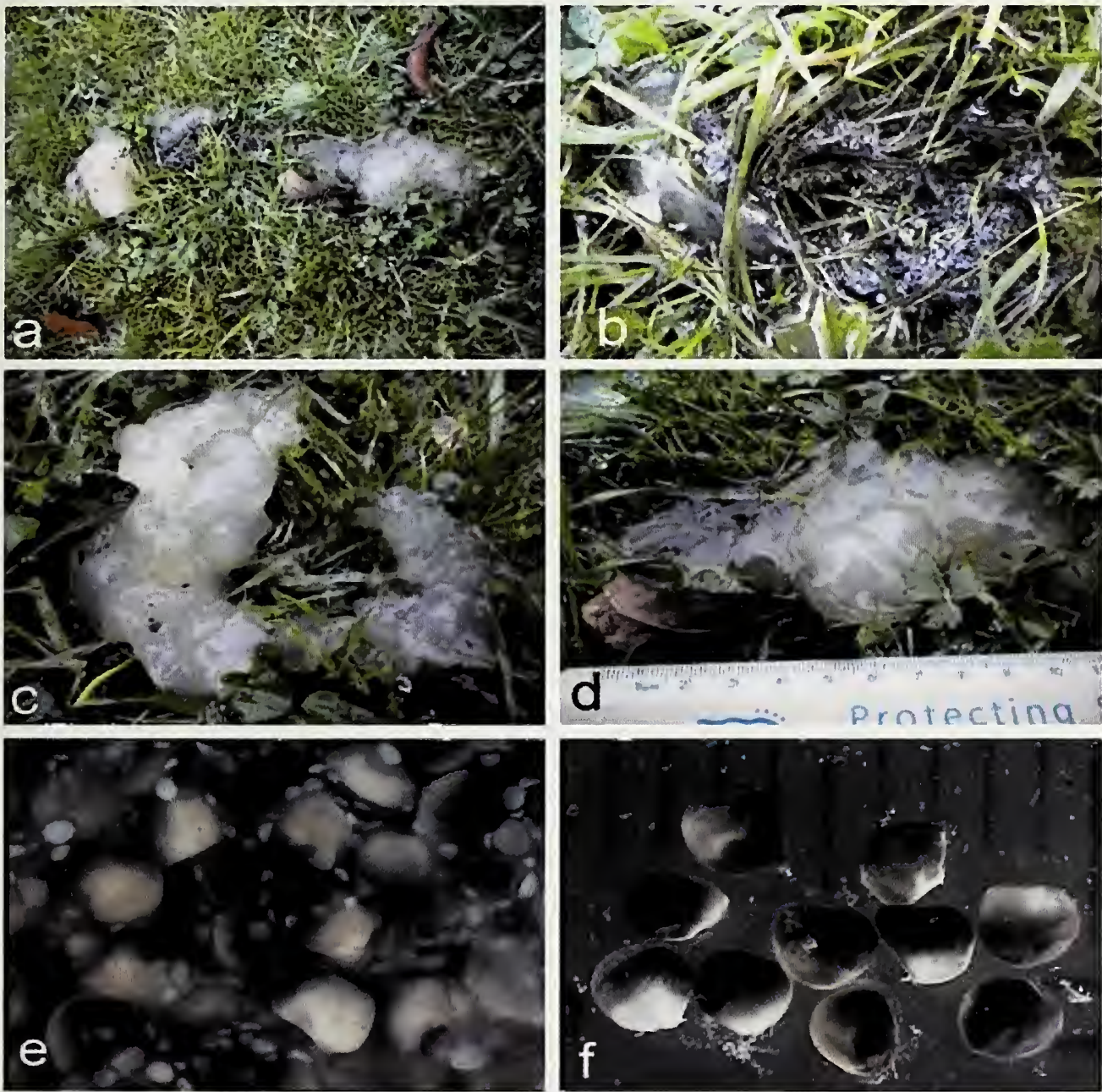
Although other types of organisms such as slugs, slime moulds or fungi often produce jelly masses these are generally of a different size, colour, or texture (Sterry & Hughes, 2009). Fungal jellies, such as crystal brain are associated with rotting logs or branches. Blue-green algal jellies (properly called Cyanobacteria) such as *Nostoc* or *Gloeocystis*,

are generally quite small with a greenish colouration.

The association of frog (or toad) eggs with some of the recent Scottish records of star jelly adds further confirmation that the most frequent source is

spawn jelly extruded from frogs (or toads) following predation. Like most occurrences of star jelly, three of the above observations were on open and exposed hillsides, suggesting that a bird of prey such as a buzzard could have been responsible.

Fig. 4. Rouken Glen, 2011. (a) star jelly and egg remnants, (b) close up of egg remnants, (c) close up of star jelly, (d) star jelly with ruler (cm), (e) detail of egg and ovary remnants, (f) eggs teased apart (mm scale marks).



Different predator species may be involved in different localities with foxes, mink, herons, and buzzards among the suspects. The increase of the population of buzzards in Scotland in recent years (RSPB, 2013) may perhaps explain an increased number of sightings of star jelly. Although the DNA analysis has to date been inconclusive, the visualevidence is sufficient to be confident that

most sightings probably derive from either frogs or toads.

The peak time for star jelly without eggs seems to be the autumn. The presence of eggs may seem more likely in spring, but some eggs are already present in frog ovaries in autumn. The oocytes of the common frog develop in annual batches, taking

three years to reach full maturity in the autumn prior to ovulation. So any adult female in autumn will have a batch of eggs ready to lay the following spring, plus two further batches at earlier stages developing to be ready for subsequent years. The eggs would normally only leave the ovary at mating time. As they pass down the oviduct each egg is surrounded by jelly. The jelly is made and secreted by tubular glands in the oviduct wall. Its volume is relatively small until the encapsulated eggs leave the oviduct and are fertilised in water; the jelly then expands enormously as it absorbs water (Duellman & Trueb, 1986).

If a predator catches and dismembers a frog the ovary will be torn apart, releasing the eggs close to the oviduct remnants. The oviducts may be stimulated to release their jelly by the trauma of the attack, and since it does not have the eggs to surround, it emerges as an amorphous mass. It will then absorb water from the soil or rain, producing the large masses that people see. If the predator removes the frog's body and takes the ovary as well, people will not see any eggs and only oviduct remnants and/or jelly will remain contributing to the 'mystery'.

It is evident that satisfactory natural explanations for the star jelly 'mystery' have been available for a long time.

For jelly originating from frogs or toads queries remain regarding what particular predators are involved and their exact mode of operation. Are the frogs or toads dismembered and the jelly or eggs discarded or are they swallowed and remnants subsequently disgorged?

How jelly deposits became associated with shooting stars in the Middle Ages is unclear. Perhaps a flying bird disgorged some jelly which then appeared to fall from the sky. It is noteworthy that, in the current 'information age', fanciful ideas and weird speculation are just as rampant as in the past. It seems the appetite for mysteries is as strong as ever. To the uninformed observer strange jelly masses scattered in the countryside will always seem a little mysterious and no doubt some wild ideas will persist on the worldwide web for some time to come!

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Johan Frederick Klotzsch's pre-1850 material in the Glasgow Museums collections and its significance

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INTRODUCTION

During the preparation of my account of mycology in Scotland (Watling, 1986) I was privileged to examine and comment on an old collection of fungi parcelled in a brown packet which was held in the Kelvingrove Museum, Glasgow and labelled 'Fungi Fleming'. The specimens are now held in the Glasgow Museums Resources Centre at Nitshill.

The Revd. John Fleming amassed a considerable collection of vascular plants, which are now found in the herbaria at the Kelvingrove Museum and Art Gallery in Glasgow and in the Royal Botanic Garden, Edinburgh. Fleming spent the first part of his career in the church but later entered the academic world. He became Professor of Natural Philosophy in Aberdeen in 1834 and ten years later was Professor of Natural Sciences in the Free Church College in Edinburgh. He became President of the Botanical Society of Edinburgh over the period 1847-50. It may be through these last connections that he came by an important fungal collection, which was evidently kept separate from his vascular plant specimens (see Jones, 1980). The fungal collections were apparently donated independently in 1902 by Major J.A. Fleming (Agnes Walker *pers. comm.*) and could have been formerly in the care of the Revd. Colin Smith. The collections are of great significance as they consist mainly of material assembled by Klotzsch, an important German mycologist working in Glasgow under the supervision of the then Professor of Botany William Jackson Hooker. Klotzsch's material was in the main transferred south along with Hooker's other material, when the latter left Glasgow to take up the Directorship of the Royal Botanic Gardens at Kew and where it became the foundation of Kew's international fungarium, (Ainsworth, 1976).

The present collections 1) throw more light on the movements of Klotzsch during 1831 than previously indicated by the material in the herbaria either at Edinburgh (E) or Kew, London (K) and 2) help to decipher some aspects of Klotzsch's handwriting not possible from the collections elsewhere in the UK. Some specimens are

undoubtedly duplicates of material to be found in E (or *vice versa*) but a clutch of his proposed new species was also revealed. Both these and the Edinburgh collections were unknown to Stafleu & Cowan (1979) when they compiled their account on Klotzsch. The Fleming specimens form the basis of this paper. For a full account of Klotzsch see Ainsworth (1976) and for an interpretation of some of his fungal collections see Reid & Austwick (1963). A full account of Klotzsch's Edinburgh collections is in preparation.

METHODS & MATERIALS

Examination of the exsiccata follows the directions in Henderson *et al.* (1969).

Abbreviations: E = Herbarium of the Royal Botanic Garden, Edinburgh; K = Herbarium of the Royal Botanic Gardens, Kew, Richmond, Surrey.

Klotzsch's abbreviations on labels: Syst. = Systema Mycologicum, 1821; Elen. = Elenchus Fungorum, 1828.

RESULTS

The specimens are arranged in taxonomic order with the proposed new species separated out as a distinct category.

1. Signed newly proposed species

Basidiomycota

Russulales: Russulaceae

Lactarius smithii. As *Inverary*, August, *mihi*.

This is *Lactarius mammosus* Fr., recognised by Fries six or so years after Klotzsch's discovery and recently redefined by Heilmann-Clausen *et al.* (1998) and not as generally interpreted in the sense of Moser (1978), which is a quite different agaric. Apart from the general characters and the comments made by Klotzsch of the distinction from *L. glyciosmus* (Fr.: Fr.) Fr., *L. uvidus* (Pers.: Fr.) S.F. Gray and *L. fuliginosus* (Fr.: Fr.) Fr., there is no doubt from the spore ornamentation alone that he recognised a new entity. This fungus was long

thought in British literature to be named after Worthington Smith apparently without any dates being checked. This fungus is named in honour of either Revd. D. Colin Smith of Inveraray, minister within the properties of the Duke of Argyll and collector of some of Klotzsch's specimens or (less likely) after Sir James Edward Smith, the founder of the Linnean Society of London.

Ascomycota

Erysiphales: Erysiphaceae

Oidium herbarum No data but possibly found in the Glasgow Botanic Garden.

This represents the anamorph of a member of the Erysiphales. No host is given so no pointer is available to help in identification but one wonders whether this is what later was called *Oidium hortensiae* Jørstad, growing on *Hydrangea*, whose teleomorph is *Microsphaera polonica* Siemaszko.

Mitosporic Fungi

Sphaeropsidales; Sphaeropsidaceae

Sphaeria (Depezea) unedonicola As *Glasgow Bot. Garden*, May 1831.

The genus *Depezea* is now considered to be a synonym of *Asteroma* (Sutton, 1980) based on the type which possesses hyaline, thin-walled, smooth, eguttulate, straight or curved cylindric conidiospores and therefore not congeneric with the asexual stage of *Diplocarpon rosae* Wolf, rose spot, which has 2-celled conidiospores and now placed in *Marssonina*. *Asteroma* is typified by *A. padi* DC., but in the literature still covers many species of fungi represented purely by darkened, sterile hyphae. This includes Klotzsch's fungus. Many authorities, e.g. Grove (1935), considered this genus to be regularly used in the past for the sporeless stages of a range of pyrenomycetous fungi, possibly species of *Mycosphaerella*. This may have been Klotzsch's thinking when indicating his new taxon. The sporeless stage of *Phyllosticta arbuti* Sacc. (= *Cheilaria arbuti* Desm.) is most commonly seen in British collections but *Septoria* is closely related, differing in the production of scoliosporic conidiospores. *Septoria unedonis* is found on fading leaves of *Arbutus*, but the name is attributed to Roberge & Desmazères and not Klotzsch. *Depezea fraxini* DC. ex St. Amans, for instance, was considered a *Septoria* by Fries (1821). Many members of *Mycosphaerella* inhabit leaves of phanerogams and have either or both *Phyllosticta* and *Septoria* anamorphic stages in their life-cycles. The Glasgow record is apparently quoted in Grove's monograph (1935) but without direct reference to Klotzsch, so the latter author recognised the distinctiveness of his find yet never published his results. A record of what might be this same species from Glamis appears in Stevenson's *Mycologia Scotica* (1879).

2. Signed & unsigned collections mainly from Inveraray August 1831.

*indicates those species found to be duplicates amongst material in the herbarium of the Royal Botanic Garden, Edinburgh and the subject of a separate article (Watling in prep.)

Basidiomycota

Agaricales

Agaricaceae

(Lepiotaceae)

***Lepiota clypeolariodes** Rea As *Agaricus clypeolaria*, near Sowerby t.14, Castle Semple, July.

Klotzsch recognised the significance of this collection and that it differed from Bulliard's *Agaricus clypeolarius*, but closely fitted Sowerby's interpretation of that species. The existence of a second agaric in the complex was not formally recognised until Rea (1922) described *L. clypeolariodes* ninety years later. *L. clypeolaria* is rare but widespread in the British Isles, being found on calcareous loams, generally under deciduous trees, whereas *L. clypeolariodes* is considered a nomen dubium by the Check List authors (Legon & Henrici, 2005). It is patently obvious that there is in Britain a fungus recognised by Klotzsch which in this author's opinion is incorrectly considered dubious!

(Lycoperdaceae)

***Bovista plumbea** Pers. As *Bovista nigrescens*, Helensburgh, July 1831.

There is a Klotzsch collection in Herb. Hooker in E with the same locality of Helensburgh, but this is *B. nigrescens* Pers. Both *B. nigrescens* and *B. plumbea* are regularly recorded and are both widespread, the former being by far the commoner. Both are to be found in grassland and may grow together with *B. plumbea* apparently more frequently in coastal areas. The two species differ microscopically particularly in the morphology of the sterigmatic remnants.

Amanitaceae

Amanita phalloides (Fr.) Link As *Agaricus phalloides*, Inverary, August 1831.

This species is generally associated in Scotland with *Quercus* and although widespread it is more frequent in western areas and in the warmer areas of the east where it occurs on more base-rich soils; it sometimes is associated also with *Fagus*.

***A. rubescens** Pers. As *Agaricus rubescens*, Inverary, 1831.

This species is very common throughout Scotland, occurring with a range of deciduous and coniferous

hosts. It is one of the first agarics to fruit after late spring rains. It is very variable and may prove to have several molecularly distinct forms or varieties.

Bolbitiaceae

Conocybe pubescens (Gill.) Kühn. As *Agaricus tener* Schaeffer, on dung in grassland.

This elegant member of the genus grows in troops surmounting horse dung 'apples'; it is common and widespread in suitable places. The characters separating this species from other members of the genus are based on microscopic characters but in macromorphology they all are very similar. The classic name of *Agaricus* or *Galera tenera* covered many of these entities that are now considered to be separate species.

Psathyrellaceae

Coprinopsis atramentaria (Bull.: Fr.) Redhead et al. As *Agaricus atramentarius* in garden on trunk.

This mushroom is a common and widespread inky cap throughout the British Isles, growing on woody remains, old stumps etc. It is more widely known as the synonym *Coprinus atramentarius* Bull.: Fr.

Psathyrella spadiceogrisea (Schaeff.) G. Betrand. As *Agaricus stipatus* Pers. Fr II p. 296, *Fagus* woodland for the most part, Pinmore, March and April 1831.

This epithet covers a whole series of *Psathyrella* spp. but the chronological information of early spring given by Klotzsch is critical and points to *P. spadiceogrisea*. This is a common agaric in the spring, often being one of the earliest of the macromycetes to fruit, especially under *Fagus*. The microscopic characters, the fact that Klotzsch indicates his fungus grew in beech woodland 'for the most part' and a range of spring dates supports the case for this common fungus. Klotzsch's note could indicate the collection is a mixture of basidiomes from slightly different sites.

Cortinariaceae

Cortinarius bulbosus (Sow.) Fr. As *Agaricus bulbosus* Sowerby, near Glasgow, September.

This species is not well known in the British Isles, although it was described originally from southern England and the only recent records of it are from the same region. At least we know what Klotzsch's interpretation was, as he quotes Sowerby as the author, and that it is not the fungus described by John Bolton under the same name some years earlier. Apparently the only record for Scotland is this of Klotzsch; see Stevenson (1879).

C. iliopodius (Bull.) Fr. As *Agaricus iliopodius* Bull., Pinmore, August.

It is really impossible to say to which taxon this collection can be referred except to indicate it is in subgenus *Telamonia*. The epithet is said to refer to the habitat (Rea, 1922) of wet places but Fries (1821) does not support this referring to the foot as muddy coloured; Fries indicates it occurs in oak and beech woods and rarely with pine. Other authors (e.g. Smith, 1908) indicate that the epithet refers to the colour of the stem, viz. as if mudded by soil. Both the latter author and Massee (1911) are apparently familiar with this fungus, although Massee (1902) had earlier omitted it from his *European Fungus Flora: Agaricaceae*.

Generally, members of this subgenus, although rather similar in colour, are rather specific in their habitat requirements and this may indicate a mixed concept, especially as members of this group are notoriously difficult to separate. Which concept Klotzsch followed cannot be ascertained, except he referred his specimens to Bulliard's plate (Bulliard, 1791), although the present author feels that there is a strong possibility that this material refers to *C. umbrinolens* P.D. Orton. This species was introduced (Orton, 1980) as a replacement name for the incorrectly identified *C. rigidus* Fr. This species is widespread and found in damp deciduous woodlands throughout southern Scotland, and on drying takes on a distinctive 'cinnamon then brownish ranging to ochraceous' (vide Berkeley, 1836; p. 88); tan-coloured according to M.C. Cooke (1881). The latter's coloured illustration (Cooke, 1883) depicts a peronate, much more sienna-coloured mushroom not in keeping with *C. umbrinolens*, which is darker in shade. There is every likelihood that Berkeley had Klotzsch's notes available to him; if these included information on this species, it would no doubt have been included in the description.

Rea (1922) apparently knew a fungus under the name used by Klotzsch quite well and states it is not uncommon in woods especially pine and beech. From the adoption of Bulliard's species name, its probable habitat and the fact that in classical literature it was considered common and widespread, it might be expected to be a fungus that Klotzsch would have encountered.

C. iliopodius more recently has been synonymised with *C. alnetorum* (Vel.) Moser, which might reflect, although incorrectly, the epithet. In the sense of M. C. Cooke (1883), which one might have thought to be more in keeping with Klotzsch, it is supposed to be the same as *C. parvoannulatus* Kühn., but this is a rare British species and is more montane in distribution. Like *C. parvoannulatus* Cooke's figure, it is true, depicts an agaric with a peronate ring, which must have influenced Kuhner's decision. These two earlier suggestions are not correct and differ considerably from *C. umbrinolens*, the latter

particularly from its small ring. *C. alnetorum* is also not possible, as it is confined to wet alder carrs and although not impossible for the Klotzsch material to be found under alder it does not fit 'common and widespread in beech, pine and mixed woodland' quoted by classical British authors.

Bulliard's plate (578) on which the species is based, is a mixture of different species, although the uppermost line of figures offer a very reasonable rendering of Orton's fungus and certainly not that of either Kühner's or Moser's interpretations.

C. torvus (Fr.) Fr. As *Agaricus torvus*, Glasgow, September.

Although fairly common in southern Britain this web-cap is less frequent in Scotland where records are, however, from widespread localities. It is usually associated with *Fagus*, but it has also been found in mixed deciduous woodland.

Entolomataceae

Agaricus prunulus, Inverary, August.

There are no spores present in this collection. In the absence of spores, a definitive identification cannot be made. If the ridged spores typical of *Clitopilus prunulus* had been present, Klotzsch's record could have been confirmed. This fungus would certainly be expected to occur around Inverary!

Entoloma (Nolanea) juncina (Kühner & Romagn.) Noordeloos As *Agaricus pascuus*, Inverary, June. In montane bogs.

Without field notes it is difficult to place this collection, although in most British texts it has been referred to as *Entoloma (Nolanea) conferendum* (Britzl.) Noordeloos (= *N. staurospora* Bres. – an even more traditional name). The spores of the Klotzsch material, however, are not star-shaped and so cannot be this species. The interpretation by Rea (1922) of this name is apparently the same as *E. vernum sensu* Lundell and is more in keeping with that of Klotzsch's material. The spore morphology, however, agrees more with that of the closely related *E. juncina*. Apparently Persoon's authentic material of *E. pascuum* Pers. has been shown to be a member of the Cortinariaceae (Singer, 1961), and so if this epithet is adopted it must be in the sense of, and based on, Fries' interpretation. This is probably the one adopted by Klotzsch as there is every indication this is a species of *Nolanea*.

Marasmiaceae

***Pleurocybella porrigens (Pers.) Singer** As *Agaricus porrigens* on pine trunk, Inverary no date.

This species is characteristic of remnant Caledonian forest. It has spread to conifer plantations in the

British Isles, is now common in Scotland and is apparently extending southwards.

Myceneaceae

Mycena pura (Pers.: Fr.) Kummer As *Agaricus purus*, September, Glasgow.

M. pura is a common, widespread and variable agaric with a strong odour of radishes. It is impossible, from the material, to say to which form Klotzsch was referring. Undoubtedly on application of molecular techniques several different taxa will be ultimately recognised within this species.

Omphalotaceae

***Gymnopus fusipes (Bull.: Fr.) S. F. Gray** As *Agaricus fusipes*, Hamilton, July 1831.

This is a typical member of the oak mycota growing on old stumps and buried roots. It is found in remnant oak forests such as in the former parkland policies frequented by Klotzsch. Although not common, it is widespread wherever there is the suitable habitat; it is common throughout England.

Physalacraceae

***Strobilurus esculentus (Wulf.) Singer** As *Agaricus esculentus*, on *Abies*, Castle Semple, March 1831.

There has been much confusion in the identity of members of this genus in the U.K., solved only in the 1990s (see Reid, 1954). Examination of Klotzsch's material in the fungaria of Edinburgh and Kew shows that he, like his contemporaries, lumped some closely related species together. *S. esculentus* is widespread and common and can be distinguished by its habitat preferences and distinctive lanceolate cystidia with crystals at their apex.

Strophariaceae

***Kuehneromyces mutabilis (Schaeff.) Singer & A.H. Sm.** As *Agaricus mutabilis*, Inverary, August 1831.

This species is very common and widespread in Scotland especially on birch stumps and trunks, although it has been recorded on a whole range of deciduous substrates in the British Isles including, but rarely, conifers.

Tricholomataceae

Lepista saeva (Fr.) P. D. Orton As *Agaricus personatus*, near Glasgow.

Formally quite a widespread and frequent agaric in Scotland growing in grassy places often near trees and used as an edible mushroom but it is dramatically less common and almost extinct in some areas as a result of urban sprawl.

Boletales

Boletaceae

Boletus edulis Bull. As *Boletus edulis*, Inverary, August 1831.

This is a keenly sought-after edible species, which is common throughout Scotland and elsewhere in the British Isles. It is associated with a whole range of deciduous trees and is also known from conifer plantations. It is often found in mixed woodland.

Gomphidiaceae

Suillus variegatus (Sow.) Richon & Roze As *Boletus variegatus*, August 1831.

S. variegatus is a common bolete of remnant Caledonian forest and less common in plantations. Although it is widespread in Scotland, it is less common throughout England

Paxillaceae

***Paxillus involutus** (Batsch) Fr. As *Agaricus involutus*, Inverary, August 1831.

This is a very common agaric throughout the British Isles and is found associated with a number of deciduous and coniferous hosts, although recent molecular studies have indicated that this is a complex of closely related taxa. Often these individual entities appear to be associated with particular hosts. It is impossible to tell to which taxon Klotzsch's specimens can be assigned.

Russulales

Lentinellaceae

***Lentinellus cochleatus** (Pers.) P. Karsten As *Lentinus cochleatus* Fr. In *Syst. Myc. I*, p.78, β . *A. denudatus* Pers. *Agaricus cochleatus* Fr. *Syst. Myc. I* p.79, on *Fagus* trunk, Inverary, August 1831.

A widespread but infrequent mushroom in Scotland growing on dead and decayed rootstocks of *Fagus* and also found on *Fraxinus*, a host it more commonly colonises in England. Persoon's variety is now generally taken as a form within the broad spectrum of basidiome shapes. This same fungus has been identified as a fairy club fungus because it can form antler-like structures.

Peniophoraceae

Peniophora quercina (Fr.) Cke. As *Thelephora quercina*, Helensburgh, July 1831.

This is one of Scotland's commonest crust fungi, especially characterised by the strongly developed, thick-walled cystidia and the dark-coloured, curled margin to the basidiome. It is widespread, growing on attached and fallen branches wherever *Quercus* is found.

Russulaceae

***Lactarius acerrimus** Britzel. As *Agaricus flexuosus*, Hamilton, July 1831.

This milk-cap is recognised by its enormous spores. The description 'pileo incarnate vitellinus' is an interesting interpretation of 'flexuosus' by Klotzsch, as present day mycologists apply the epithet to a widely occurring grey-capped milk-cap of beech woods. This interpretation is not in keeping with Klotzsch's remarks and some authorities have suggested this epithet should not be used because of confusion. *L. acerrimus* is not a common fungus anywhere in the U.K., less so in Scotland, but a western distribution would be expected for this oak associate. There are some well-developed remnant oak forests in the vicinity of Hamilton.

***L. glyciosmus** (Fr.) Fr. As *Agaricus glyciosmus*, Pinmore, September 1831.

This is a common and widespread milk-cap associated with *Betula* throughout the British Isles and noted for its odour of desiccated coconut.

L. piperatus (L.) Fr. As *Agaricus piperatus*, Inverary, August 1830

This is a widespread milk-cap of rich deciduous woodland where it is associated with both *Fagus* and *Quercus* but it is nowhere common. It was confused by classic authors in the past with what was recognised at a much later date as an independent species, viz. *L. glaucescens* Crossl. This species differs in spore morphology from *L. piperatus* and in the strong orange reaction with potassium hydroxide solution. Both taxa are relatively common in Scotland.

L. pterosporus Romagn. As *Agaricus fuliginosus*, Inverary, August 1831.

In classic British literature no distinction was made between the various segregates of *L. fuliginosus* (Fr.) Fr., which are now all now recognised as separate entities and supported by molecular data. *L. pterosporus* has very distinctive winged basidiospores demonstrated in the Inverary material. This species is probably more widespread in Scotland than the records suggest, and is here associated with *Fagus* and sometimes *Quercus*.

L. vellereus (Fr.) Fr. As *Agaricus vellereus*, Inverary, August 1831.

This spectacular milk-cap is infrequent but widespread in Scotland and is associated with a range of deciduous tree species. On microscopic characters this collection would be referred to var. *velutinus* (Bertill.) Bat.

L. volemus (Fr.) Fr. As *Agaricus volemus*, Inverary, August 1831.

This is a characteristic member of the Scottish oak mycota, recorded most frequently in the south and west, but possibly declining in other parts of the British Isles.

Russula grata Britzel. As *Agaricus foetens*, Garscube, July 1831.

Much confusion has reigned over the identification of members of the *R. foetens* group with *R. foetens* Fr. in its restricted sense not as frequent as *R. grata* and its allies, which are all species described at later dates. The spore morphology of each of the constituent species is slightly different and Klotzsch's material possesses the basidiospores of *R. grata*, which is in fact probably the commonest member of the group. It is to be found in woodland policies with a range of mixed trees both deciduous and coniferous.

Stereaceae

Stereum rugosum (Pers.) Fr. As *Thelephora rugosum*, Castle Semple, May 1831.

A very common and widespread curtain-fungus which when damaged in the fresh condition produces a red latex-like substance. It grows on standing and fallen trunks and attached branches often at the base of tree stocks or where the main trunk has been damaged; it may cover several metres in extent. It is commonly found on *Fagus* and on *Corylus* root stocks, where it may be weakly parasitic but then saprobic. It is recorded on several other hosts, including *Rhododendron*, but apparently rarely on conifers.

Hymenochaetales

Hymenochaete rubiginosa (Dicks.) Lév. As *Thelephora rubiginosa* on *Quercus*, Inverary, August 1831.

This species is a characteristic member of the oak forest mycota, although it has been recorded, albeit rarely, on other members of the Fagaceae, Betulaceae, Ulmaceae and even Salicaceae. It is common and widespread throughout the range of *Quercus* in Scotland.

Polyporales

Coriolaceae

Trichaptum abietinum (Pers.) Ryvarden As *Polyporus abietinus forma resupinatum*, Eaglesham, March 1831.

This is an exceedingly common bracket fungus on coniferous trash and brashings in plantations, including those of *Pinus*, *Larix* and *Picea*. It is also found on decaying, fallen trunks of pine in their

early stages of decay and may take a resupinate form. The latter is the form represented by Klotzsch's specimen, as he rightly notes.

Meripilaceae

Grifola frondosa (Dicks.) S. F. Gray As *Polyporus frondosus* Inverary Revd. R. D. C. Smith, September

This is a widespread bracket fungus in the British Isles but nowhere common, although it is less frequent northwards and then it is found in the west or in remnant ancient oak woods. It is usually found on *Quercus*, but it is recorded from many phanerogams though rarely on conifers.

Uredinales

Pucciniaceae

Puccinia festucae Plowright As *Aecidium periclymenis*, Hamilton, July 1831.

This is the aecidial stage of a rust fungus named by Schumacher (1803) for which the sexual stage was not demonstrated until ninety years later by Plowright (1893). The aecidial stage as shown by Klotzsch's specimen is on *Lonicera periclymenum*; the teleuto- and uredospore stages form on various species of *Festuca*. This rust is rarely reported in Scotland, especially in its aecidial stage, but it is apparently widespread.

Phragmidiaceae

Phragmidium tuberculatum J. B. Müll. *Uredo rosae* Inverary August 1831.

Klotzsch's name refers to an asexual stage (*Uredo*), which in this case was later transferred to *Phragmidium*, a genus which in fact lacks the stage now restricted to *Uredo*. *P. tuberculatum* attacks a whole range of cultivars of rose in addition to members of the *Rosa rugosa* group, although it is rare on the closely related *Rosa canina*. It is infrequent in Scotland, although probably more widespread than records suggest.

Ustilaginales

Ustilaginaceae

Ustilago hordei (Pers.) Lagerh. As *Caeoma segetum* Link. No locality and no data.

This smut also occurs under the name *Ustilago segetum* Roussel. It is found in the spikelets of *Hordeum vulgare* (barley) and in Klotzsch's time this smut was frequently seen infecting plants. Nowadays, with recent plant breeding schemes producing resistant forms, it is more rarely seen. The present collection, however, could be considered the material on which Rabenhorst (1856) made his combination *Ustilago segetum* var. *hordei* (Pers.) Rabenh. There are several varieties of *U. segetum* in the literature and most are now

considered to be independent species with their own specific host range.

Ascomycota

Pezizales

Pezizaceae

Otidea alutacea (Pers.: Fr.) Masee As *Peziza cochleata*, *Eaglesham*.

The taxon now called *O. cochleata* (L.: Fr.) Fuckel has slightly larger spores than Klotzsch's specimens - spores 13.2-15.4 x 6-7.2µm; apart from a slightly darker disc it is otherwise very close and probably indicates Klotzsch was relying on macroscopic characters for identification. It is widespread and rather common in woods along tracks and on bare areas of soil.

Helotiales

Bulgariaceae

Bulgaria inquinans (Pers.: Fr.) Fr. As *Bulgaria inquinans*, *Inverary*.

This is a common disc-fungus on fallen trunks and branches of *Quercus* but also less commonly recorded on *Castanea*, *Betula*, *Carpinus* and *Ulmus*. This species is characterised by the upper four spores in the ascus being dark brown whilst the lower four are hyaline.

Sclerotiniaceae see **Botrytis** below

Diatrypales

Diatrypaceae

Diatrype stigma (Hoffm.: Fr.) Fr. As *Sphaeria stigma*, *Bankhead*, *May 1831*.

This is an exceedingly common fungus on fallen branches of a wide range of deciduous trees and especially abundant on *Crataegus* branches. The fungus forms fuscous or purplish black effuse crust-like fruiting bodies on decorticated wood, with the roughened surface revealing the presence of the perithecia.

Eutypa lata (Pers.) Tul. & C. Tul. As *Sphaeria stigma*, on *Fraxinus*, *Bankhead*, *May 1831*.

This also is an exceedingly common fungus on fallen branches and sometime larger diameter twigs of a range of deciduous trees, including *Fraxinus*, although *Acer* possesses its own specific member of the genus. *E. lata* forms effuse fruiting bodies within the decorticated wood through which the perithecia protrude to give a roughened texture on handling.

Dothideales

Dothideaceae

Mycosphaerella hedericola Lindau As *Sphaeria (Depezea) hedericola*, on *Hedera*. No locality and no date.

This is a widespread micro-fungus forming dark brown patches on living *Hedera* leaves in the centre of which are irregular spots that enclose the minute perithecia.

Hysteriales

Hysteriaceae

Hysteroglyphium fraxini (Wahlenb.) Corda As *Hysterium fraxini*, *Hamilton*.

This fungus was rather widespread and quite frequent in former times on the bark of branches and twigs of *Fraxinus*, but is now uncommon in the British Isles except for some parts of Wales.

Hypocreales

Hypocreaceae

Hypocrea rufa (Pers.) Fr. See **Trichoderma** below

Hypomycetaceae

Hypomyces chrysospermum Tul. As *Sepedonium mycetophilum*, on *putrescent fungus*. No locality and no date.

This is a very common fungus, which attacks a wide range of members of the Boletales, converting the fruiting bodies into a bright yellow mass of thick-walled conidia. In this anamorphic stage it is better known as *Sepedonium chrysospermum* (Bull.) Link. The teleomorph of *H. chrysospermum* is rather rare in Scotland.

Hypomyces sp. See **Mycogone rosea** Link below

Mitosporic Fungi

Moniliales

Botrytis cinerea As *Sclerotium durum* var. *Hyacinthii*, *Inverary*, *Aug. 1831*. *Elench.pg. 44*.

Sterile sclerotia are notoriously difficult to identify to species level but *S. durum* is consistently taken as belonging to the 'Grey Mould', whose teleomorphic stage is *Botryotinia fuckeliana* (de Bary) Whetzel. As indicated by Klotzsch, the sclerotia are very common on the dead scapes of the English blue bell. The connection of the sclerotia and the grey mould was obviously made by Klotzsch although not fully appreciated that the *Botrytis* on '*Sclerotio duro ad caulis hyacinthus*' was one and the same thing. The actual mould had formed the sclerotia as one of its asexual stages. Thus he had collected *Botrytis* twice. It is in fact the very common and troublesome 'Grey mould' that is the scourge of horticulturists.

Mycogone rosea Link As *Mycogone rosea*, on *putrescent fungus*, *Inverary*, *August 1831*.

This is an anamorphic *Hypomyces* which is widespread although far less frequent than *Sepedonium chrysospermum*, q.v. The former grows on a range of *Agaricus* spp. and *Inocybe* species, two quite different genera of agarics in different families, which indicates there is a complex of

species all with the upper cell of the conidium rose-coloured and the lower, smaller cell, pale.

Trichoderma viride Tode As *Trichoderma viride*, July 1830.

T. viride is really a complex of species with the teleomorph of the true *T. viride* generally considered to be *Hypocrea rufa* (Pers.) Fr., a member of the Hypocreales. The differences can be seen only microscopically, but the green pulvinate colonies on rotten wood are characteristic.

There is a Klotzsch collection from Garscube as *Ag. melaleucus* Pers., which would now be considered to be *Melanoleuca melaleuca* (Pers.) Murrill. It is in a bad state of preservation but lacks the amyloid ornamented basidiospores that characterise members of this genus. The identity is unknown.

DISCUSSION

The Fleming material, especially when coupled with material from the Edinburgh and Kew Botanic Gardens, emphasises why the young Klotzsch had been chosen by Hooker to come to Britain and undertake the exercise of curating his fungal specimens and expand his fungal herbarium. It is obvious that Klotzsch had been well schooled by his former Professor, J.H.F. Link, to the extent that he recognised collections that were new to science. He failed to follow many up with formal publication, returning to Germany and moving on in his career. The range of species he collected allows present-day workers to gain some idea of the distribution in the 1800s of the widespread taxa collected and the concept for these species then understood. The identity of the elusive *Cortinarius ileopodius* may well have been solved had people taken note of the specimens in Fleming's care. The fact that Fleming possessed this very important collection of Klotzsch material indicates he was in contact with the cream of Scottish mycologists.

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SHORT NOTES

Plantains in Lanarkshire (VC 77)

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INTRODUCTION

The following is an account, in alphabetical order, of the botanical names, of the occurrence of the members of the plantain Family (*Plantago* spp.) in Lanarkshire.

Plantago arenaria (branched plantain)

An introduced species, very scattered in south and central Britain, less common than formerly. It was recorded as a seed alien from the Ryding and Maryburgh coups by Grierson in 1922.

Plantago coronopus (buck's horn plantain)

A coastal plant, with scattered inland records, mainly in England. In Lanarkshire two plants seen in 2002 about 50 yards apart on the near side verge of the M8 in Drumoyne, Glasgow [close to lesser sea-spurrey (*Spergularia marina*)] were considered to be this taxon; at least as sure as one can be by a front seat passenger, when caught in a traffic jam and travelling at 5-10 mph! (NS 5464). A definite record was made in 2011 (J. R. Hawell) when a cluster of nineteen specimens were noted on damp bare ground by a gravel pit, south of Drumclog (NS 639379) (Fig. 1).



Fig. 1. Buck's horn plantain from near Drumclog. *Plantago lanceolata* (ribwort plantain)

Abundant throughout Britain. The first Lanarkshire record was that of Ure from Stonelaw in 1793. Ribwort plantain grows on lawns, pastures and other grassy waste places. It is also a frequent

colonist of lower bing slopes. There are modern records for all but one full (0.5 SW) and four partial quadrants (*i.e.*, 113 out of a possible 118). Despite its name, the leaves are not always lance-shaped. Some have been seen that are intermediate between it and the greater plantain (at one time called greater broad-leaved plantain).

Flowering spikes have ranged from 9 to 79 cm. The following variants have been noted.

A specimen with persistent prominent stamens was noted growing in short turf in the Glasgow Necropolis in 2004 (NS 6065) and a clump in rough ground in the King George V Dock complex in 2009 (NS 5366) (Fig. 2).



Fig. 2. Ribwort plantain flower heads with prominent stamens from King George V Dock.

'Carmen Miranda' (Cragg-Barber, 2005), the form with leaves growing from the top of the spike was seen in 2006 near Newlandscroft (NS 599519) and on waste ground in Rutherglen in 2009 (NS 6062). It was so called from the likeness to the headgear worn by the actress of that name! (Fig. 3a & b).



Fig. 3a. Drawing of the actress Carmen Miranda with her distinctive headgear.

A specimen with a triple flower head was collected from the road side at Canderside Toll in 2001 (NS 7748) (Fig. 4)

A pubescent form was noted on the Marlage bing, south-east of Larkhall (NS 7948) in 2006. It was very hairy all over, apart from the flower head.



Fig. 3b. Ribwort plantain specimen with leaves growing from the top of the spike, the 'Carmen Miranda' form, from Newlandscroft.

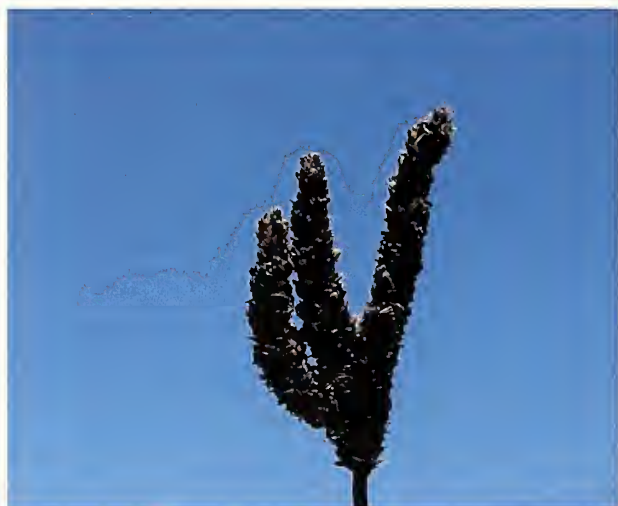


Fig. 4. Ribwort plantain with triple flower head from Canderside Toll. Specimen photographed against the sky for greater clarity.

***Plantago major* (greater plantain)**

This species is one of the most common plants in the wild in Britain. It was first recorded in

Lanarkshire in 1813 by Hopkirk who did not give it a locality. The plant being so common, he probably thought that unnecessary. There are modern records for 110 of the 118 quadrants; all full quadrants and all but eight partial ones, of which most have only a small part in the vice-county.

This is a trample tolerant plant commonly found on paths and track sides, but also on waste ground, lawns and other grassy places.

The smallest specimen noted had a total leaf length of 3.8 cm. Near Bothwell Castle (NS 689594) a solid clump approximately 1 m long and 0.5 m broad was seen in 2011. The average leaf stalk was 23 cm, the blade being 15 cm long and 5 cm broad (*i.e.*, a total length of 38 cm). The average flower stalk was 32 cm and the flower spike 27 cm, giving a total length of 59 cm. Definitely *P. major*! *Plantago intermedia* has never been recorded in Lanarkshire.

***Plantago major* 'rosularis' (rose plantain)**

This variant was described and illustrated in Gerard's Herbal of 1633. He referred to it as 'spiked rose plantain' and commented that, "*It bears a very double flower upon a short stem like a rose, of greenish colour tending to yellowness. The seed groweth upon a spikie tuft above the highest part of the plant*". A single rose plantain was seen in 1998 in the middle of an overgrown track at Wester Kitchside (NS 608568) (Fig. 5)



Fig. 5. Rose plantain variant of greater plantain from West Kitchside.

***Plantago maritima* (sea plantain)**

Common around the coast, inland sites being mostly on mountains. In recent years it has been described as rare by salt-treated roads. In 1793 Ure reported it from the wayside, near Whitemoss (now in the middle of modern East Kilbride). Patrick (1832) gave a record from 'Gour's Braehead Avondale'. In *Notes on the Botany of Avondale* (R. Turner, 1880) there is the statement, "*Owing to the entirely inland nature of the county, there is a total absence of*

marine plants, and such as are peculiar to coasts and seaboards. In Avondale, however, near Drumclog, a flowering plant is to be found- the Sea Plantain (*Plantago maritima*)- which usually prefers a coast habitat...but it is not uncommon in upland districts by mountain streams...and this Avondale station affords a good instance of its occurrence in such situations". In 1859 J. H. Balfour found it on rock on banks of the River Cart somewhere between Cathcart and Busby (which may have been VC 77, depending on which bank). The burns near Drumclog have been searched recently without success.

In 2009 a large and a moderate clump was noted at the south-east side of the A73 north of Robertson (JRH; NS 948288) and in 2011 single plants were seen on the eastern verge of the A70, south-east of Tarbrax (JRH; NT 039546) and on the north side of the same road east of Glenbuck Loch (NS 763233) (Fig. 6)

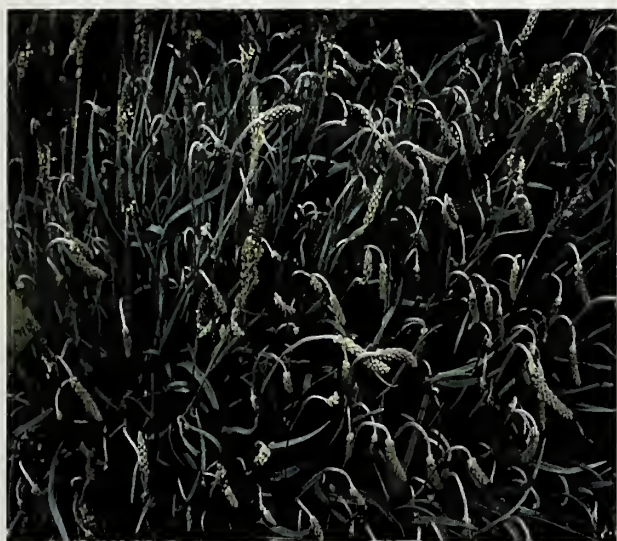


Fig. 6. Sea plantain from the side of the A73 near Robertson.

***Plantago media* (hoary plantain)**

Native in neutral to basic grassland and locally common in Britain north to central Scotland. The occurrence of the plant in Lanarkshire was noted by Hopkirk in 1813 without a specific locality. Henneidy (1865) listed Dennistoun but considered that it was found only as an introduction with grass seed, not retaining its place so as to become permanent in pastures. Patton collected it in the Bothwell Castle area in 1913 (GL).

We recorded it in 1993 from alkaline grassland by a steel foundry at New Stevenston (NS 761598) and it was seen in what was described as a herb-rich paddock/recreation area at Greenhills, East Kilbride (JRH; NS 5870) in 2002.

Despite being a rather drab genus, occurrences, physical variations and variants of *Plantago* spp. are of interest.

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First record of the scalloped ribbonfish *Zu cristatus* (Bonelli, 1819) (Lampriformes: Trachipteridae) from N.W. European waters

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On the 8th of September 2001, the MFV Audacious II (BF83) captured a single specimen of the scalloped ribbonfish *Zu cristatus* (Bonelli), east of the Rockall Bank (56°20'N, 14°00'W), while trawling at a depth of 380 metres. This specimen was identified from a photograph supplied by the skipper of the vessel (Fig. 1). Although most of the tail section was missing due to net damage, based on the photograph and the known dimensions of the tray on which the specimen was laid out (500 x 250

mm), the estimated length from the tip of the snout to the vent (SV) was c. 550 mm. The following diagnostic features were visible in the photograph: ventral profile scalloped and sharply constricted behind the vent; mouth small and terminal; no anal fin; paired pectoral and pelvic fins present (Palmer, 1986).

Although the scalloped ribbonfish is rarely recorded, particularly in commercial trawls, it is generally considered to be mesopelagic (0 – 800 m) with a circumglobal distribution in tropical and temperate waters, including: Madeira, Azores and Mediterranean Sea (N.E. Atlantic); Gulf of Mexico, Cuba, Florida, Bermuda and Canada (N.W. Atlantic); South Africa (S.E. Atlantic); Kenya (Indian Ocean); Japan, Philippines and New Zealand (Indo-Pacific); California, Peru and Galapagos Islands (E. Pacific) (Palmer, 1961; Heemstra & Kannemeyer, 1984; Robins *et al.*, 1986; Bianco *et al.*, 2006; www.fishbase.org). Despite being previously recorded on several occasions in the N.W. Atlantic from the Gulf of Mexico northwards to Sable Island, Canada (44° N, 63° W), it has rarely been recorded from the N.E. Atlantic and only as far north as the Azores (38.98° N, 31.37° W) (www.fishbase.org).

In the Mediterranean Sea adult and juvenile specimens (< 1219 mm total length L_T), as well as larvae and ova, have previously been recorded, albeit sporadically. Large specimens (> 800 mm L_T) have been caught mainly during summer months at depths ranging from 150 to 800 m, while juveniles have occasionally been observed free swimming in shallow coastal waters. The species is thought to spawn between May and August in the Strait of Messina (Bianco *et al.*, 2006; Psomadakis *et al.*, 2007; Bradai & El Ouaer, 2012).



Fig. 1. Scalloped ribbonfish *Zu cristatus* captured east of the Rockall Bank on 8 September 2001.

The specimen described here represents the first record of the scalloped ribbonfish from N.W. European waters, and extends the species range by c. 2311 km in the N.E. Atlantic. Although possible that this specimen was carried across from the N.W. Atlantic *via* the North Atlantic Drift, it is also possible the species may occur more widely in the N.E. Atlantic yet remains undetected. Tortonese (1958) suggested that the species was rarely

captured because mesopelagic habitats are poorly sampled.

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Insect and spider records from Islay in 2011 (Arachnida, Coleoptera, Hemiptera and Hymenoptera)

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This note presents records of insects and a spider from Islay, Inner Hebrides, collected while on a visit to the island in July 2011. The visit lasted a week and coincided with some of the best weather of that indifferent summer, and fieldwork was not hindered by wind or rain. Collecting effort concentrated on aquatic and semi-aquatic invertebrate species, with several collected species apparently new to the island according to published sources and maps on the National Biodiversity Network (NBN) (www.nbn.org.uk). Voucher material for these records have been deposited with the Hunterian Museum, University of Glasgow (Entry No. 1392).

The visit was primarily to carry out an entomological assessment of two RSPB reserves: Smaull Farm and the Oa. Smaull Farm on the north-west coast contains areas of wet heath and modified bog, coastal grassland and arable ground and includes part of Loch Corr. This lake is known for its entomological interest, in particular species of water beetle. The coastal strip west of Loch Corr is drained by several short streams that flow into the Atlantic. The most interesting of these streams flows along Gleann na Muchdalaich, a short glen with interesting habitat, including an area of sedge and moss-dominated mire at Dun Bheolain. The Oa is an elevated coastal site at the south-east of the island with heath and blanket bog containing several lakes, including Loch Kinnabus, one of the largest lakes on the island. Visits were made to several other localities, including Loch Gruinart, which is a large sea loch on the northern side of the island, and Ardnave Loch, a shallow lake behind dunes.

Arachnida, Araneae

Argyroneta aquatica: Loch Corr, NR225695, 24 July 2011. No previous records have been mapped for Islay or any other Scottish island (Harvey *et al.*, 2002). It is present on Rathlin Island, Co Antrim, the nearest Irish island to the south (*pers. obs.*).

Coleoptera

Stenus cicindeloides: Dun Bheolain, NR213688, 29 July 2011. Found on mossy fen, swept from sedges and rushes. A widespread species (Lott & Anderson, 2011) but few Scottish mainland records are shown on the NBN and none from any of the other Scottish islands.

Stenus oscillator: Dun Bheolain, NR213688, 29 July 2011. Found on mossy mire/poor fen, taken with pond net. This is a rare northern species of acid mires, wet heaths and bogs (Boyce, 2004; Lott & Anderson, 2011). This appears to be the first record from Islay and the habitat would appear typical for the species. Only two mainland Scottish records are shown on the NBN. One male was dissected to confirm the identification.

Hemiptera

Hebrus ruficeps: Loch Corr, NR224694, 24 July 2011. Common on wet mosses in wet heath/poor fen by lake. Dun Bheolain, NR213688, 29 July 2011. Common on wet mosses in sedge and moss-rich mire in small glen. The habitat at both sites is typical of where it occurs in Ireland (*pers. obs.*). There are only a few Scottish mainland records and none from the islands (Huxley, 2003).

Corixa punctata: Smaull RSPB reserve, NR214674, 29 July 2011. Adults common on shallow artificial wetland; two males dissected. The distribution of *C. punctata* and the very similar *C. iberica* in Scotland are discussed and shown in Huxley (1997, 2003) and Angus (2006a, b). Huxley (1997) reported *C. iberica* on Islay and considered that old records of *C. punctata* from the island were likely to be *C. iberica*, so only that species was mapped on the atlas (Huxley, 2003). The 2011 *C. punctata* specimens from Islay may represent a recent colonisation. A similar situation has been noted on the north coast of Northern Ireland where *C. punctata* has appeared on sites on Rathlin Island that held *C. iberica* in the 1980s (Nelson, 1995; *pers. obs.*).

Micronecta poweri: Loch Kinnabus, NR301426, 25 July 2011. Adult found in shallow water on stony margins of lake. Typical habitat for the species but unaccountably only a single adult was caught. In the author's experience the species is normally present in numbers in suitable habitats. Dolling (1983) mentions the occurrence of *M. minutissima* on Islay, but this is likely to be incorrect. *Micronecta poweri* was formerly known as *M. minutissima* and old records under that name probably refer to this species. True *M. minutissima* is confined in Britain to south-east England (Huxley, 2003). Huxley (1997) lists both *M. poweri* and *M. minutissima* from Islay but indicates the *M. minutissima* record as probably incorrect. However, neither species was shown as occurring on Islay in Huxley (2003). This record at least provides confirmation of its presence on Islay.

Chartoscirta cincta: Dun Bheolain, NR213688, 29 July 2011. Adults swept from sedge beds.

Salda littoralis: Loch Gruinart, east shore near Killinallan, NR303714, 28 July 2011. A single adult collected on upper beach of sea loch with patchy saltmarsh.

Saldula palustris: Loch Gruinart, east shore near Killinallan, NR303714, 28 July 2011. Adults common on upper beach of sea loch with patchy saltmarsh.

Saldula saltatoria: Loch Kinnabus, NR301426, 25 July 2011. Many collected on exposed stony shore of lake. Ardnave Loch, NR286728, 28 July 2011. Common on bare ground on shore of lake. Loch

Gruinart, east shore near Killinallan, NR303714, 28 July 2011. Adults common on upper beach of sea loch with patchy saltmarsh.

No records of sallow bugs from Islay are shown on the NBN maps. *Saldula littoralis* and *Saldula saltatoria* are the commonest species in their respective genera and their presence on Islay is not unexpected. On the basis of comments in Dolling (1983), it appears that *Chartoscirta cincta* and *Saldula palustris* are new to the Islay fauna.

Hymenoptera

Bombus pratorum: Kinnabus, NR298426, 25 July 2011. A single male collected in flowery meadow. This common bumblebee has apparently not been recorded from Islay before, although there is a record from the neighbouring island of Jura.

My work on Islay was funded by the RSPB. Thanks are due to Mark Gurney (RSPB) and Garth Foster for information on the island and to Malcolm Ogilvie, Becky Williamson and Ian Brooke for advice and hospitality during my visit.

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ELECTRONIC SOURCES

National Biodiversity Network; www.nbn.org.uk.
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Continuing decline of the grey squirrel population on Loch Lomondside

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An increasing scarcity of the hitherto well established North American grey squirrel *Sciurus carolinensis* in the woodlands of east Loch Lomondside first drew my attention during the late 1990s. The suspected cause of this decline is potentially the result of population expansion into the area by predatory pine marten *Martes martes* (Mitchell, 2001). That pine marten are capable of successfully pursuing grey squirrel through the tree canopy to affect a kill was witnessed by a gamekeeper on the Buchanan Castle Estate in early April 2004 (Mitchell, 2005). Further observations in the same area showed that by the beginning of 2012 the grey squirrel, once familiar at bird feeding tables, was no longer observed in gardens in the village of Drymen. Additionally, there were several sightings of pine martens in this area during the previous months.

Less information is available regarding any change in the population status of grey squirrels elsewhere on Loch Lomondside. An exception to this is the ever popular Balloch Park, situated on the loch's southern basin, where grey squirrels have always been relatively easy to observe. During the course of a short walk, a dozen or more individuals could until recently be seen foraging on the grass lawns. By the spring of 2012, however, a visitor to the park would have been lucky to come across more than one or two grey squirrels.

Several factors may be involved in the Balloch Park grey squirrels' fall in numbers; one being disturbance from tree-felling that had taken place in order to contain an outbreak of a conifer disease. Secondly, there were unverified reports of the systematic culling of nuisance grey squirrels by local residents whose gardens adjoin the park (Lewis Pate, *pers. comm.*). Finally, there remains the possibility of predation by pine martens within Balloch Park. Their presence within this park was confirmed in September 2010 when a single pine marten was live-trapped and released at an adjacent farm (*Lennox Herald* 1/10/2010).

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The bizarre Eustigmatacean alga, *Pseudostaurastrum limneticum* (Borge) Chodat, in a shallow, nutrient-enriched Scottish loch: new to the British Isles

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The yellow-green alga *Pseudostaurastrum* is a unicellular genus belonging to the phylum of Eustigmatophyta, formerly transferred from the Xanthophyta by Schnepf *et al.* (1996). Recently, the phylogenetic position of *Pseudostaurastrum* was investigated using 18S rRNA gene sequences and it was confirmed that *P. limneticum* and *P. enorme* form a sister branch to other Eustigmatophyceans included in the study (Hegewald *et al.*, 2007; Přibyl *et al.*, 2012).

Freshwater phytoplankton communities are important indicators of the bio-integrity of standing waters and are, therefore, used by the Scottish Environment Protection Agency (SEPA) to assess the ecological status of more than 80 freshwater lochs in Scotland. Phytoplankton samples are collected at varying frequencies, but at a minimum are taken three times a year between July and

September. Sub-samples of phytoplankton (preserved in Lugol's iodine) are examined using an inverted microscope and analysed according to standard procedures, with counts of approximately 400 individuals being routinely conducted (Brierley *et al.*, 2007; CEN, 2004 & 2008). These data not only provide a means of monitoring water quality across Scotland, but also provide information on species distributions, including rare or previously unrecorded species, at the local to national level.

Pseudostaurastrum limneticum (Borge) Chodat occurred sparsely (1 – 2 cells per 10 ml sub-sample) in phytoplankton samples collected from Loch Flemington during the spring and summer months of 2011 and 2012. This comprises the first known record of *P. limneticum* in the U.K. (D. John, *pers. comm.*). Previously, *P. enorme* (Ralfs) Chodat and *P. hastatum* (Reinsch) Chodat were the only two species of *Pseudostaurastrum* recorded from freshwater habitats in Great Britain (Johnson, 2011).

Loch Flemington is located in Nairnshire, around 12 miles east of Inverness, Scotland (NGR: NH 81026 52040). It is a small lake (0.15 km² area), with a shallow mean depth (0.75 m), and is a high alkalinity (annual mean 63.9 mg L⁻¹ as CaCO₃ over 2011-12), meso-eutrophic [annual mean total phosphorus (TP) concentration 39.4 µg L⁻¹ over 2011-12] water body. Due to a long-standing history of potentially toxic cyanobacteria or 'blue-green algae' blooms associated with high phosphorus concentrations, Loch Flemington was subject to a novel lake management approach involving the application (March 2010) of the phosphorus-binding agent, Phoslock®, with the primary goal of improving water quality conditions (Meis *et al.*, 2013). Monitoring of this ecosystem scale experiment continues and includes responses in the phytoplankton community to manipulation of the internal phosphorus load (Lang *et al.*, *unpub. data*). SEPA holds stakeholder interest in the ecological recovery of Loch Flemington, and in collaboration with the Centre for Ecology and Hydrology supports a 'citizen's science' monitoring scheme with local stakeholders to closely monitor water quality through analysis of monthly phytoplankton samples and water chemistry.

Pseudostaurastrum limneticum (Fig. 1a, b) ranges in diameter from 20 – 25 µm, and this bizarre alga can be plate-like, tetrahedral or polyhedral in shape, with cell corners projecting into branches or 'arms' (Schnepf *et al.*, 1996). Morphologically, *P. limneticum* lies in the spectrum between the stout, highly-branched body of *P. enorme* (Fig. 1c), and the slender, tapering form of *P. hastatum* (Fig. 1d). Though *P. limneticum* has been documented worldwide (www.algaebase.org), more specifically this species was found in a small eutrophic lake in

Sicily (Barone, 2003), meso-eutrophic and eutrophic ponds in the Czech Republic (J. Kaštovský, pers. com; www.sinicearasy.cz), and occupying the phosphorus polluted shore waters of Lake Victoria in Tanzania (Mbonde *et al.*, 2004). A preference for nutrient enriched conditions has also been noted elsewhere (e.g., Ott & Oldham-Ott, 2003). These accounts are consistent with the occurrence of *P. limneticum* in the phytoplankton community of Loch Flemington, although this is being further investigated (Lang *et al.*, unpub. data). Ascertaining whether our specimens are a genetic match for *P. limneticum* found in globally distributed freshwater habitats warrants future research.

Pseudostaurastrum limneticum is an unusual species of alga for U.K. freshwaters, and although ecological knowledge is somewhat fragmentary, its occurrence in general suggests elevated nutrient levels. Above all, this represents an exciting new find for the British Isles.

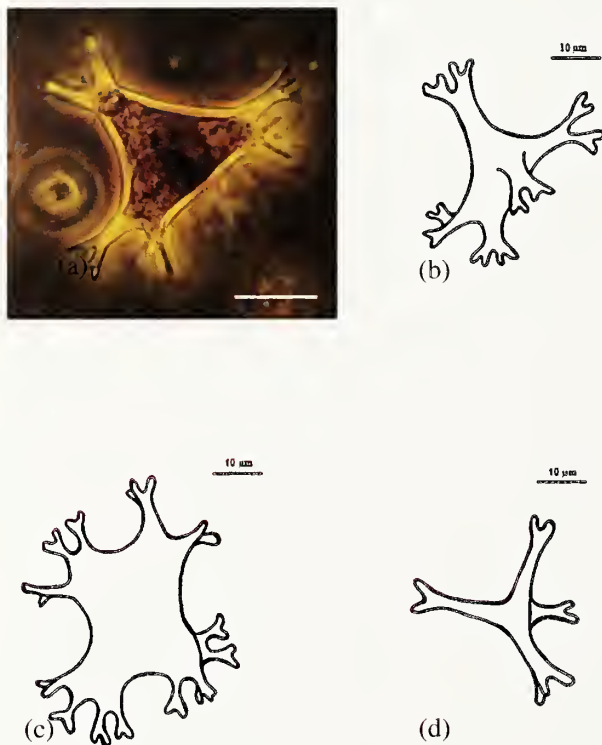


Fig. 1. *Pseudostaurastrum* spp. (a) Photomicrograph of *P. limneticum* preserved in Lugol's iodine. Scalebar, 10 µm. (b) Line drawing of *P. limneticum*. (c) Line drawing of *P. enorme*. (d) Line drawing of *P. hastatum*.

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Thanks especially to Professor David John (Natural History Museum, London) for formally verifying the identity of *P. limneticum*. We are grateful to Dr Elizabeth Haworth (Freshwater Biological Association) for confirming that no U.K. records of *P. limneticum* pre-existed in the Fritsch Collection. We thank SEPA for providing the water chemistry data for Loch Flemington. We also thank Dr Kevin

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The solitary planktonic chrysophyte *Dinobryon faculiferum*: an alga species typically restricted to brackish environments found inhabiting a freshwater loch in northern Scotland

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Dinobryon faculiferum (Willén) Willén [= *Dinobryon petiolatum* T. Willén] is a solitary planktonic chrysophyte ('golden') alga (Lang *et al.*, 2011) typically restricted to brackish environments (Willén, 1963), and hence not currently recognized in John *et al.* (2011). One of several solitary life forms in the genus, *Dinobryon faculiferum* is distinguished from similar species (e.g., *D. borgei*) by a prominently elongate spine, length usually 40 – 60 µm (Willén, 1963), although this characteristic feature can at times be quite variable (Willén, 1992) (Fig. 1a, b). Although primarily documented from sea water (e.g., Unrein *et al.*, 2010), *D. faculiferum* has also been recorded amongst the phytoplankton of a saline lake in Venezuela (Lewis & Riehl, 1982) but never previously from U.K. freshwater habitats.

In the course of analysing phytoplankton samples collected as part of the Scottish Environment Protection Agency's ongoing assessment of the ecological status of freshwater lochs in Scotland (Lang *et al.*, 2013), *Dinobryon faculiferum* was observed sporadically (e.g., 1 – 3 cells per 100 ml sub-sample) in Loch Kinord, between 2009 and 2012, and often co-occurred with a number of other *Dinobryon* species (e.g., *D. bavaricum*; *D. borgei*; *D. crenulatum*; *D. divergens*; *D. sociale*; *D. suecicum*).

Loch Kinord is a freshwater loch in northern Scotland, located approximately 50 km inland from the North Sea coastline. Its water quality characteristics have been described elsewhere (Lang *et al.*, 2012). Perhaps the water environment

provided by Loch Kinord is slightly brackish (annual mean sodium and chloride concentrations respectively 9.23 mg L⁻¹ and 18.05 mg L⁻¹ in 2012), which generally fits in with the current distribution pattern of *D. faculiferum* (Willén, 1963; Unrein *et al.*, 2010). However, this constitutes the first known record of the species from British freshwaters (D. John, *pers. comm.*).

Although widely-regarded as a marine species, we have shown that *D. faculiferum* is also capable of inhabiting freshwater environments. Whether our Scottish specimens of *D. faculiferum* are genetically similar to coastal populations derived from elsewhere in Europe remains to be determined, but identifies an area that would benefit from further research.

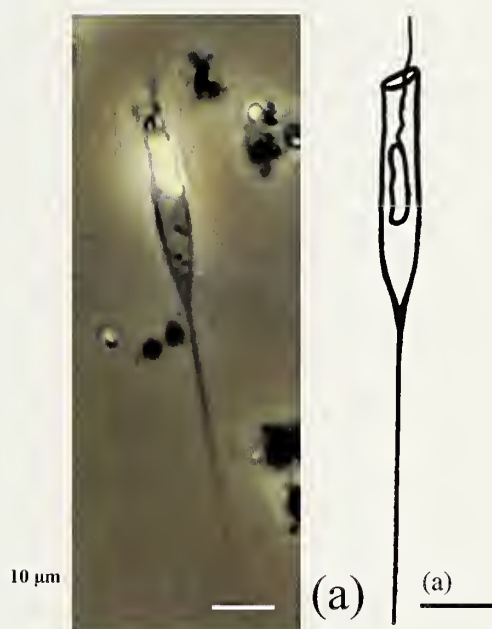


Fig. 1. *Dinobryon faculiferum*. (a) Photomicrograph of *D. faculiferum* preserved in Lugol's iodine. Scalebar, 10 µm. (b) Line drawing of *D. faculiferum*.

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***Ollicola vangoorii* (Chrysophyceae, Chromulinales): an unfamiliar loricate protist newly documented in U.K. freshwaters from a southern upland loch, Scotland**

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Ollicola vangoorii (W. Conrad) Vørs [= *Calycomonas vangoorii* (W. Conrad) J.W.G. Lund] is a flagellate protist belonging to the chrysophyte ('golden') algae (Lang *et al.*, 2011), with a coastal temperate to polar distribution (Vørs, 1992). The protective envelope of this alga is characterized by transverse striations that produce the distinctly corrugated appearance of the species' vase-like lorica (Lund,

1960; Starmach, 1985) (Fig. 1a, b). Until now, *O. vangoorii* has not previously been recorded in U.K. freshwaters (G. Novarino & D. John, *pers. comm.*).

In the course of analysing phytoplankton samples collected as part of the Scottish Environment Protection Agency's ongoing assessment of the ecological status of freshwater lochs in Scotland (Lang *et al.*, 2013), small numbers (5 – 10 cells per 100 ml) of *O. vangoorii* were found in Loch Grannoch during the summer months of 2012. Loch Grannoch is situated in a largely afforested catchment of the southern uplands of Scotland (NGR: NX 54153 69674). It is an elongated lake with a surface area of c. 1.14 km², characterized by an acid-sensitive (annual mean -0.82 mg L⁻¹ as CaCO₃ in 2012) and slightly mesotrophic water chemistry [annual mean total phosphorus (TP) concentration 15.4 µg L⁻¹ in 2012].

Although *O. vangoorii* is typically known as a marine taxon (e.g., Novarino *et al.*, 2002), and is hence not currently featured in John *et al.* (2011), the species has also been documented from less saline Danish inland waters (G. Novarino, *pers. comm.*). Therefore, its occurrence in a freshwater environment is probably not unexpected, and furthermore suggests the species is adapted to a wide salinity range. This may well depend upon distinct eco-physiological variants. However, there seem to be no noticeable morphological differences in relation to salinity (G. Novarino, *pers. comm.*). Whether the *O. vangoorii* found to occur in freshwater is genetically similar to those inhabiting the marine environment, remains to be determined.

Besides the potential for a mixotrophic existence [i.e., capacity to derive energy from photosynthesis and by ingesting bacteria (Novarino *et al.*, 2002)], the ecological significance of *O. vangoorii* is poorly understood. Nonetheless, we present another interesting algal find that is completely new to the freshwaters of the British Isles.

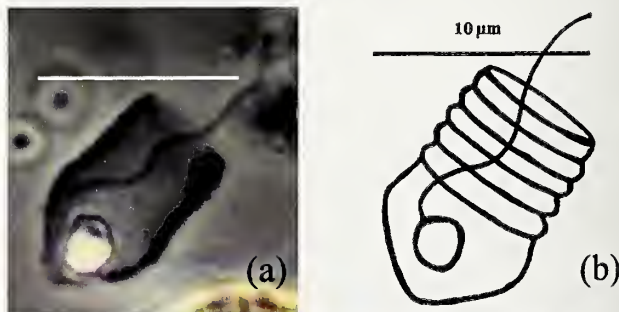


Fig. 1. *Ollicola vangoorii*. (a) Photomicrograph of *O. vangoorii* preserved in Lugol's iodine. Scalebar, 10 µm. (b) Line drawing of *O. vangoorii*.

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Thanks especially to Dr Gianfranco Novarino and Professor David John (Natural History Museum, London) for formally verifying the identity of *O.*

vangoorii. We are grateful to Dr Elizabeth Haworth (Freshwater Biological Association) for confirming that no U.K. records of *O. vangoorii* pre-existed in the Fritsch Collection. We thank SEPA for providing the water chemistry data for Loch Grannoch. We also thank Dr Kevin Murphy (University of Glasgow) for proof-reading an earlier version of the manuscript.

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Chlorococcalean, or green alga species, belonging to the genus *Desmatractum* West et G.S. West (1902) are solitary cells enclosed by a spindle-shaped ‘fusiform’ envelope, typically broader in the middle and tapering towards the poles (John & Tsarenko, 2011).

In the course of analysing phytoplankton samples collected as part of the Scottish Environment Protection Agency’s ongoing assessment of the ecological status of freshwater lochs in Scotland (Lang *et al.*, 2013), *Desmatractum spryii* Nicholls was found to occur frequently (e.g., 10 – 20 cells per 100 ml sub-sample) in Loch Mochrum during the summer months of 2012. Loch Mochrum lies within the Machars Peninsula of Dumfries and Galloway, south-western Scotland (NGR: NX 30255 53183). The loch has an area of c. 0.9 km², is characterized by relatively low alkalinity (annual mean 6.57 mg L⁻¹ as CaCO₃ in 2012) and meso-eutrophic water chemistry [annual mean total phosphorus (TP) concentration 42.43 µg L⁻¹ in 2012].

Of the nine *Desmatractum* species recognized, only one of these, *D. bipyramidatum* (Chodat) Pascher is currently known to British freshwaters (Lund, 1942; John & Tsarenko, 2011). Hence, this finding of *D. spryii* in a Scottish peninsula loch comprises an entirely new record for the U.K. (D. John, *pers. comm.*).

Desmatractum spryii was originally described from the phytoplankton of several hardwater lakes in Ontario, Canada (Nicholls *et al.*, 1981), and has rarely been documented since, aside from Norway (Reymond & Skogstad, 1983), Germany and the Ukraine (Hegewald & Tsarenko, 1998). *Desmatractum spryii* (Fig. 1a, b) can be unmistakably differentiated from other members of the genus, by distinct ridges present in the equatorial region of the cell wall, a consistent characteristic of the species (Nicholls *et al.*, 1981; Reymond & Skogstad, 1983; Reymond & Kouwets, 1984).

Our observations, together with other published work, imply that *D. spryii* occupies a broad ecological niche of ranging alkalinity and nutrient conditions. Although we may presume that genetically these findings constitute the same species, for now, it seems the bio-indicator value of *D. spryii* remains undefined. Nonetheless this species encompasses a noteworthy discovery and a welcome addition to the British algal flora.

The fusiform green alga *Desmatractum spryii* (Chlorophyta, Chlorococcales): a noteworthy discovery made in a peninsula loch, S.W. Scotland

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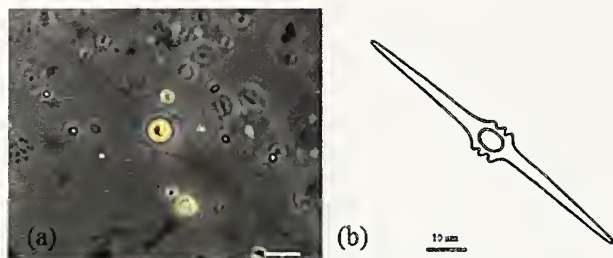


Fig. 1. *Desmatractum spryii*. (a) Photomicrograph of *D. spryii* preserved in Lugol's iodine. Scalebar, 10 µm. (b) Line drawing of *D. spryii*.

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Thanks especially to Professor David John (Natural History Museum, London) for formally verifying the identity of *D. spryii*. We are grateful to Dr Elizabeth Haworth (Freshwater Biological Association) for confirming that no U.K. records of *D. spryii* pre-existed in the Fritsch Collection. We thank SEPA for providing the water chemistry data for Loch Mochrum. We also thank Dr Kevin Murphy (University of Glasgow) for proof-reading an earlier version of the manuscript.

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The rare smut fungus *Urocystis fischeri* (Urocystidales, Ustilaginomycotina) from the Outer Hebrides, Scotland, with notes on its systematic position

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Urocystis fischeri Körn. is a smut fungus that forms blisters in the leaves of several species of sedges *Carex* spp. Vánky (2012) gives 28 species and one hybrid as hosts. Vánky (1994) has 23 and one of these respectively in Europe (Fig. 1), but most of these are not known as hosts in the British Isles. There are fewer than 30 distinct records of *U. fischeri* from the British Isles according to FRDBI (www.fieldmycology.net/FRDBI), mainly from *Carex flacca* Schreb. (glaucous sedge), with a few records from *C. panicea* L. (carnation sedge) and one from *C. nigra* (L.) Reichard (common sedge).



Fig. 1. *Urocystis fischeri* on the leaves of the sedge *Carex rostrata*, Berchtesgaden National Park, Bavaria (Courtesy of Julia Kruse).

A specimen of *Carex demissa* Hornem. (common yellow-sedge) from Traigh Mheilen, N. Harris, Outer Hebrides, Scotland (NA9914) infected with a leaf smut was collected on 15 July 2012 and determined by P.A.S. as *U. fischeri*; M.L. confirmed the determination. The morphology of *U. fischeri* observed with a light microscope differed only slightly compared with the species description given by Vanky (1994): sori were light to dark reddish-brown (not lead-coloured); spore balls globose to ovoid (not irregular), 18 - 37 µm (not 20 - 40 µm), composed of 1 - 3 spores (not 4); spores 12 - 15 x 14 - 17 µm (not 11 - 16 x 14. 5 - 19 µm); sterile cells 5 - 11 µm (not 5 - 15 µm).

Carex demissa appears to be a new host species in Britain for this smut. The locality is an area of damp machair grassland, close to the sea (Fig. 2), which is heavily sheep-grazed. There were a few infected shoots together in one spot, but no other infections were seen. However, the heavily-grazed sward would have made other specimens easy to overlook, it was necessary to be on hands and knees to see the smut at all! There are three other records from the Outer Hebrides for *Urocystis fischeri*:

- Barra, July 1935, on *C. flacca* (Campbell 1936).
- Baleshare Island, North Uist, 10 Sep 1968, D.M. Henderson, on *C. flacca*, specimen in E.
- Butt of Lewis, [NB56], Lewis, 5 Aug 1973, R.W.G. Dennis, on *C. nigra* (Dennis, 1975).

R.W.G. Dennis undertook extensive investigations of microfungi in the Hebrides over many years (Dennis, 1986), but detected rather few specimens. Otherwise there are not many smut recorders, so it is likely that the scarcity of records reflects considerable under-recording. However, the host plants are common, and if infections were frequent, more reports would be expected, so only a tiny proportion of shoots is apparently infected.



Fig. 2. Machair habitat where *Urocystis fischeri* was collected on *Carex demissa* (in a damp area towards the right of the picture).

The internal transcribed spacer (ITS) and large subunit (LSU) rDNA sequences for this specimen have been determined (for methods see Lutz *et al.*, 2004, primers used: ITS1f/LR5), and added to GenBank (accession no. KF668284) where they were the first sequences for *U. fischeri*. The voucher specimen was deposited in Kew (accession no. K(M)188731).

To elucidate the relationship of the *U. fischeri* specimen within the genus *Urocystis* its ITS and LSU sequences, respectively, were analysed within datasets covering all the *Urocystis* species available in GenBank (for methods see Lutz *et al.*, 2012b). The phylogenetic hypothesis derived from both the ITS and LSU analyses (data not shown) revealed no clear pattern of phylogeny. Most relations between species were not resolved. According to the ITS analyses *U. fischeri* may be closely related to *U. muscaridis*, but more distantly related to some other *Urocystis* species. The taxonomic position of *U. fischeri* within the genus *Urocystis* is therefore apparently confirmed, although the wider relationships within this large genus await further clarification.

Strict host specificity at the species level was demonstrated recently for several smuts (e.g., Kemler *et al.*, 2009; Lutz *et al.*, 2008, 2012a; Piatek *et al.*, 2012, 2013a, b; Savchenko *et al.*, 2013), and it is possible that there will be variations within *U. fischeri* on its range of host species. The collection of further specimens on various hosts and molecular phylogenetic analyses are needed to assess this.

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New records of smooth newt (*Lissotriton vulgaris*) in Lanarkshire

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During 2013, surveys were undertaken of ponds throughout the South Lanarkshire town of East Kilbride for the presence or likely absence of amphibians. A total of 21 ponds were selected using the criteria given by the Freshwater Habitats Trust (undated: see References) and surveyed during the months of April and May in the evenings by torchlight. The species detected during these survey visits at each site are given in Table 1 and the OS coordinates of the ponds are listed in Table 2. Of these 21 ponds, two were found to contain smooth newts. The NBN (National Biodiversity Network) Gateway lists smooth newts as occurring within East Kilbride area at 10 km resolution but offers no records at higher resolution within a 3 km

buffer of the town. A request for amphibian records from Glasgow Museums Biological Records Centre and South Lanarkshire Council yielded no additional records of this species within the official boundary of the town with a 3 km buffer.

On the evening of 10th April 2013 the so-called "Fire Pond" at Calderglen Country Park (Fig. 1) off the A726 (NS 65413 52864) was surveyed by torchlight and net from approximately 22:00 until 23:00. One male smooth newt was found during the survey and an estimated 170 clumps of common frog (*Rana temporaria*) spawn using the methods given by Griffiths et al. (1996) with 13 adults alongside 10 adult common toads (*Bufo bufo*). This site was surveyed only once. The Fire Pond is circular and approximately 400 m² in area. The pond is reportedly deep (pers. comm. South Lanarkshire Council Ranger Service, April 10th, 2013) and infrequently cleaned out. The pond is man-made and steep-sided with old bricks; it is fenced off and public access to it is restricted. The site had approximately 80% macrophyte cover when surveyed, including both submerged and emergent vegetation. No fish were noted and waterfowl presence was restricted to one or two mallard ducks (*Anas platyrhynchos*). The terrestrial habitat is moderate in quality but restricted in area, as the immediate vicinity of the pond offers foraging opportunity and minor hibernation opportunity for amphibians, with barriers to dispersal including amenity grassland, public access paths and a football pitch. The water was clear and its quality appeared good in view of the abundance and diversity of the aquatic invertebrates that were present.

The second pond I call GSO (Glasgow Southern Orbital) Business Park SUDS (Sustainable Urban Drainage System) (Fig. 2), a man made SUDS pond at the side of the A727 (NS 60085 55429). On the early morning of 23rd April, four adult male smooth newts in full breeding form with obvious large black spots, lobed toes on the hind feet and smoothly undulating crest from the rear of the head continuing along the vertebrae and on to the tail (Smith, 1951; Inns, 2009; Beebee, 2013) were noted by torchlight. In addition, four male and one female palmate newt (*Lissotriton helveticus*), five small unidentified female newts (*Lissotriton* sp.), and one clump of common frog spawn were noted. The site was surveyed again on 5th May when a male and female smooth newt were noted alongside 21 palmate newts and eight unidentified female small newts. The pond is roughly elliptic and approximately 350 m² in area with two culverts, one running in from drains at the nearby GSO Business Park and one running out into a small burn leading to Kittoch Water. There was little macrophyte cover apart from emergent vegetation at the pond's edge. No fish were noted and no

waterfowl were seen. The terrestrial habitat is moderate in both quality and area with good opportunity for foraging and hibernation by amphibians, but subject to disturbance from local development, as new industrial units are due to be built and associated machinery accesses the area in this regard. The water was clear and, from the number of damselfly larvae present, it would be reasonable to assume of good quality.

These sites are at opposite ends of East Kilbride with no linking habitat and at each site there are two other ponds within 1 km. The two closest to Calderglen Fire Pond were also surveyed and no smooth newts were found. Those closest to GSO Business Park SUDS were not within the 2013 survey area.

Table 1. Numbers of amphibians detected in East Kilbride ponds in 2013 (data from Paterson, 2013). The numbers are peak counts of each species found in each of the 21 ponds surveyed during the 2013 season. Ponds are given in order from West to East. For the common frog, unless stated otherwise, the values are the number of spawn clumps; for all other species they are peak head counts by torchlight. Abbreviations of pond names are explained in Table 2. ad = adults.

Pond	common frog	common toad	palmate newt	smooth newt	small newt (Unid.)
TRS	50	29	0	0	1
PRS	17	26	0	0	0
OP	1	42	0	0	0
DP	0	0	0	0	0
GBS	1	0	21	4	8
PPP	60	4	4	0	0
HW	41	0	9	0	9
LRS	97	119	0	0	0
HL	155	20	0	0	0
LWP	65	64	0	0	0
CP	50	16	1	0	2
LGP	2(ad)	14	0	0	0
AS	173	0	0	0	0
BQS	0	0	0	0	0
GRS	3	0	0	0	0
SSP	9	0	0	0	0
CDP	25	2	0	0	0
CFP	170	10	0	1	0
CWP	9	0	1	0	0
FP	55	0	1	0	4
CRP	16	12	4	0	7

Table 2. Locations of ponds given as Ordnance Survey coordinates.

Pond	Coordinates
Thornton Road SUDS	NS 59444 54170
Peel Road SUDS	NS 59492 63976
Ocein Pond, Ocein Drive	NS 59546 53473
Disraeli Pond, Disraeli Way	NS 59766 53659
GSO Business Park SUDS	NS 60085 55429
Peel Park Pond, Redwood Drive	NS 60427 54956
Hairmyres Woods	NS 60495 54470
Lindsayfield Road SUDS	NS 60680 51918
Heritage Loch, Stewartfield Way	NS 62637 55773
Langlands West Pond, Greenhills Road	NS 62923 51727
Crosshill Pond, Auldhouse Road	NS 62976 51061
Langlands Golf Course Pond	NS 63319 50876
Amphibian Site, Hurlawcrooks Road	NS 63903 60984
B&Q SUDS, Mavor Avenue	NS 64175 56228
Greenhills Road Sub Station	NS 64226 51942
Sainsbury's Small Pond	NS 64272 51503
Calderglen Park Old Duck Pond	NS 65251 52642
Calderglen Park Fire Pond	NS 65413 52864
Calderglen Wildlife Pond	NS 65514 52657
Fred's Pond, Calderglen Country Park	NS 65847 54715
Calderside Road Disused Pit	NS 66761 55257



Fig. 1. Calderglen Fire Pond, Calderglen Country Park, East Kilbride.

No other sites with smooth newt records are known within 3km of the town's boundary and no verifiable or precise records can be found for this region. Each pond is located close to a site at which development has recently taken place (GSO Business Park and K-Park Training Academy, Calderglen). K-Park Training Academy received some negative attention from the local newspaper during construction when old beech trees were removed to make way for football pitches. It is common knowledge within the town that K-Park was not universally well received with letters of complaint being issued by individuals who use Calderglen Country Park in which K-Park was built for dog walking and other outdoor pursuits. On this account, I tentatively speculate that there is a small possibility that smooth newts have been introduced at these sites by local individuals who, having seen the orange bellies of the males coupled with a crest, assumed that they were handling protected great crested newts (*Triturus cristatus*) and introduced them at these sites. This is a tentative and highly speculative proposal and further, more comprehensive survey effort is required in the local area to determine the true extent of the spread of the smooth newt before any further conclusions can be made.

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Fig. 2. GSO Business Park SUDS, East Kilbride.

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Ecological distribution of the water grimmia (*Schistidium agassizii* Sull. & Lesq.), a nationally scarce semi-aquatic moss in the U.K., with a new record from an upland tributary of the River Dee, N.E. Scotland

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Bryophytes comprise a highly successful group of plants that have managed to exploit environmental conditions generally unsuitable for sustaining vascular plant growth (Stream Bryophyte Group, 1999; Lang, 2010). For example, in fast flowing and boulder-strewn upland headwater streams, bryophytes are often the dominant form of plant life, tolerating being pummeled by harsh current velocities and dislodged or rolling substratum (Lang, 2010; Lang & Murphy, 2012). These stream bryophytes encompass a relatively small proportion of the moss and liverwort flora capable of occupying habitats frequently inundated with water (Stream Bryophyte Group, 1999). Recent work has placed emphasis on the potential value of bryophyte communities for making integrated bioassessments of water quality, and through their prevailing life strategies, also reveal important information concerning the physical character of rivers (Lang & Murphy, 2012; Vieira *et al.*, 2012).

The water grimmia, *Schistidium agassizii* Sull. & Lesq. [= *Grimmia agassizii* (Sull. & Lesq.) Jaeg.] is a

semi-aquatic moss species belonging to the family Grimmiaceae, characterised by predominantly dark green-brown to blackish foliage (Birks & Birks, 1967; Smith, 2004). Tending to form discrete clumps, the moss can be found pressed against the surfaces and crevices of partially submersed rocks in rivers (Holmes, 1976; Lang, 2010), though little is understood about its habitat ecology (http://www.bbsfieldguide.org.uk/sites/default/files/pdfs/mosses/Schistidium_agassizii.pdf).

Schistidium agassizii is designated as nationally scarce (Averis *et al.*, 2012), occurring in only thirteen myriads (U.K. Ordnance Survey grid unit areas of 100 x 100 km², designated by a two letter code) across Great Britain (<https://data.nbn.org.uk/Taxa/NHMSYS0000310590>). In Scotland, it is considered a species of principal importance for biodiversity conservation (<http://www.scotland.gov.uk/Topics/Environment/Wildlife-Habitats/16118/Biodiversitylist/SBL>).

A northerly distribution of *S. agassizii* is somewhat apparent (Hill *et al.*, 1992; Fig. 1), with the majority of the U.K. records derived from Scottish sites (Table 1), mostly located in the Highlands.



Fig. 1. Grid map of distribution records of the water grimmia, *Schistidium agassizii* in the U.K. (reproduced with permission from [https://data.nbn.org.uk/Taxa/NHMSYS0000310590/Grid Map](https://data.nbn.org.uk/Taxa/NHMSYS0000310590/Grid%20Map)). © Crown copyright and database rights 2011 Ordnance Survey [100017955].

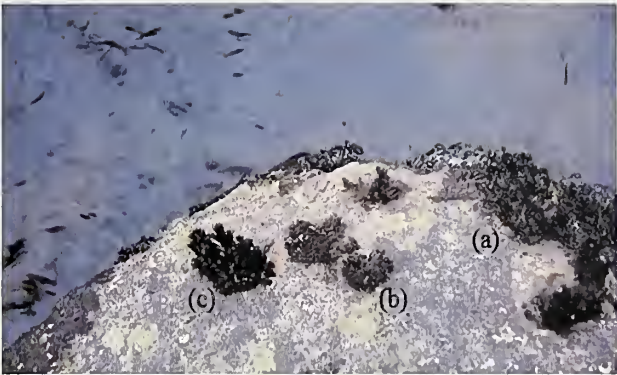


Fig. 2. Photograph of *Schistidium agassizii* (a) co-occurring with *Blindia acuta* (b) and *Racomitrium aciculare* (c) on a partially submersed rock in the Girnock Burn, Royal Deeside.

Table 1. Verified U.K. records of *Schistidium agassizii* (<https://data.nbn.org.uk/Taxa/NHMSYS0000310590>); OS myriad pre-fixed with superscript letter ‘S’, ‘E’ or ‘W’ denoting whether moss populations were derived from Scotland, England or Wales, respectively.

U.K. NGR myriad (100 x 100 km ² resolution)	Number of U.K. hectads containing records of <i>S. agassizii</i> (10 x 10 km ² resolution)	Number of individual U.K. records of <i>S. agassizii</i> per myriad held by NBN database, to January 2014
^S NN	8	23
^S NH	6	14
^S NC	5	21
^S NO	5	10
^S NJ	2	6
^S ND	1	2
^S NG	1	2
^S NR	1	2
^S NS	1	3
^S NX	1	1
^E NY	3	28
^E SD	1	1
^W SH	3	7
Total	38	120

Of the 120 verified records of *Schistidium agassizii* held by the NBN database, to January 2014 for the U.K. (<https://data.nbn.org.uk/Taxa/NHMSYS0000310590>), nearly all are from riverine locations (with the species hitherto being recorded from 24 Scottish rivers and streams, together with two lochside

locations, as well as records from Ben Lawers (e.g., Birks & Birks, 1967), and Polgown Craigs on the north bank of the Scaur Water, in the upper catchment of the R. Nith). Within the R. Dee catchment in Aberdeenshire, there are two existing records from a single site on the river, approximately 2.5 km downstream of Ballater. During botanical surveys conducted in 2005 and 2006, undertaken as part of a larger research project (Lang, 2010), we additionally observed this moss species on repeated occasions, usually limited to sizeable substratum within the stream channel at Hampshires' Bridge (NO 312 912), on the Girnock Burn, a small tributary of the River Dee (joining the river about 5 km upstream of Ballater). The underlying catchment geology of the Girnock Burn is chiefly granitic, interspersed with base-rich rocks that includes a small proportion of limestone (Soulsby *et al.*, 2007; Tetzlaff *et al.*, 2007; Lang & Murphy, 2012), producing a streambed morphology characterised by a high abundance of cobbles and the presence of some larger boulders (Lang, 2010). Its water physico-chemistry is principally oligotrophic (phosphate concentration usually < 0.003 mg L⁻¹), circumneutral (mean pH 7.10) and reasonably well-buffered (mean alkalinity 23.08 mg L⁻¹ as CaCO₃) against acid-induced spate events (Lang, 2010). We found that *Schistidium agassizii* typically co-occurred with *Blindia acuta* (Hedw.) Bruch & Schimp. and *Racomitrium aciculare* (Hedw.) Brid. (Fig. 2), together forming a small biomass, low diversity species assemblage displaying stress/disturbance resistant traits (e.g., small leaves, wiry stems, streamlined morphology), indicative of intensely scoured and unstable habitat conditions (Lang & Murphy, 2012). This association has been noted to occur elsewhere in Scotland (e.g., the Bruar Water: http://www.sepa.org.uk/water/water_regulation/advertised_applications/idoc.ashx?docid=51ea134b-77c7-4b14-8e16-432c997a4e53&version=-1), and northern England (e.g., upper stretches of the River Tees: Holmes, 1976). Furthermore, the inferences drawn by Lang & Murphy (2012) regarding the adaptiveness of turf mosses such as *Schistidium agassizii*, *Blindia acuta* and *Racomitrium aciculare* for enduring frequently disturbed conditions in high latitude upland streams, generally agree with wider research findings (e.g., Muotka & Virtanen, 1995; Virtanen *et al.*, 2001).

We report a newly confirmed record of the nationally scarce water grimmia, *Schistidium agassizii*, the ecological distribution of which fits in with previous occurrences documented by the NBN Gateway. Although the moss may be genuinely rare, perhaps it is simply under-recorded or mistaken for *Schistidium rivulare* (Brid.) Podp., which is similar. Therefore, further work on the habitat ecology of *S. agassizii* would certainly benefit conservation knowledge concerning this particular species.

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ELECTRONIC RESOURCES

http://www.bbsfieldguide.org.uk/sites/default/files/pdfs/mosses/Schistidium_agassizii.pdf

<http://www.scotland.gov.uk/Topics/Environment/Wildlife-Habitats/16118/Biodiversitylist/SBL>

<https://data.nbn.org.uk/Taxa/NHMSYS0000310590>

https://data.nbn.org.uk/Taxa/NHMSYS0000310590/Grid_Map

http://www.sepa.org.uk/water/water_regulation/advertised_applications/idoc.ashx?docid=51ea134b-77c7-4b14-8e16-432c997a4e53&version=-1

Some uncommon desmids (Chlorophyta, Zygnemophyceae) encountered in the phytoplankton of Scottish lochs

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Desmids are an idiosyncratic group of green algae (Chlorophyta, Zygnemophyceae) comprising two highly symmetrical halves or 'semi-cells', leading either a solitary or colonial existence (Coesel & Krienitz, 2008). They are usually found dwelling amongst the algal communities of standing freshwater habitats, widely ranging from upland bogs to lowland lakes (John & Williamson, 2009). Although some genera are often perceived as taxonomically 'easier' (e.g., *Micrasterias*) because they are intrinsically better defined than others (e.g., *Staurostrum*), the intricate semi-cell architecture and morphological continua displayed by desmids can make accurate species-level identification notoriously challenging (Brook & Williamson, 2010). For this reason, and coinciding with the limited accounts in at-hand published floras (themselves based on reliable records), there may be an inclination towards subjectively lumping desmid specimens under the appropriate genera or species of similar appearance. However, adopting this 'broad brush' approach is likely to have implications for establishing precise estimates of algal biodiversity and also, up to a point, water quality assessments, potentially masking the vulnerability of freshwater ecosystems to environmental threats such as eutrophication and climate change at the microscale.

In the course of analysing phytoplankton samples collected as part of the Scottish Environment Protection Agency's ongoing assessment of the ecological status of freshwater lochs in Scotland (see Lang *et al.*, 2013), a number of relatively uncommon desmids were discovered during the 2009 to 2010 monitoring period. In particular, six species (Table 1; Fig. 1a - f) did not match any desmids described by Brook (2002) for the British Isles. These did, however, more closely resemble taxa recorded from western Ireland as illustrated by John & Williamson (2009), suggesting an eco-geographical overlap of desmid assemblages between this region and north-west Scotland (from where most of the uncommon desmids presented here were derived). Three of the six species have since been included in the second edition of *The Freshwater Algal Flora of the British Isles* (Brook *et al.*, 2011), whilst the other desmids remain to be fully depicted (Table 1).

It seems that some of the less common desmids, defined by Brook *et al.* (2011) as those typically observed on fewer than five sampling occasions, may have been overlooked. Why? Firstly, it is a painstaking task documenting all of the c. 800 desmid species currently known to occur in Britain and Ireland, though this apparently overwhelming feat has been accomplished elsewhere (e.g., Brook & Williamson, 2010; John *et al.*, 2011). Nevertheless, a published flora is not necessarily a definitive list. Extensive surveillance monitoring, akin to that of

SEPA's sampling framework, can be crucial in uncovering specimens new to a locality (e.g., Lang *et al.*, 2013), or even to science, thereby adding records to the catalogue through time. For the most part, however, this work is conducted from the perspective of meeting legislative requirements

(e.g., EU Water Framework Directive: European Commission, 2000), and though widespread across Scotland, does not entail an exhaustive sampling programme. Neither is its primary aim to capture desmid diversity.

Table 1. Floristic list of some uncommon desmids, their distribution and abundance in Scottish lochs monitored by SEPA during 2009 and 2010. Abbreviations: LA = low alkalinity; MA = moderate alkalinity; HA = high alkalinity; VS = very shallow; S = shallow; D = deep. Initials 'DW' denote desmids recorded by David Williamson.

Desmid species	Sample location (NGR)	Lake typology	Annual mean pH (2009–2010)	Annual mean Total Phosphorus concentration(µg L ⁻¹) (2009–2010)	Desmid abundance	Included in Brook <i>et al.</i> (2011)?	Highlighted in Brodie <i>et al.</i> (2007)?
<i>Cosmarium dybowskii</i> Gutwinski 1896 (Fig. 1a)	Loch Ussie (NH 50448 57194) Loch Veyatie (NC 20154 12305)	MA; VS HA; S	7.53 7.54	16.76 8.71	Infrequent Infrequent	Yes	Yes, Endangered – rare and habitat endangered (category 2) 1 record by DW
<i>Staurastrum cornutum</i> W. Archer 1881 (Fig. 1b)	Loch Naver (NC 61807 36706)	LA; S	6.46	5.11	Infrequent	Yes	No
<i>Staurastrum grande</i> Bulnheim 1861 (Fig. 1c)	Loch Stack (NC 27710 43163)	LA; S	6.69	6.83	Infrequent	Yes	No
<i>Staurastrum kouwetsii</i> Coesel 1996 (Fig. 1d)	Loch Langavat (NG 04687 89217)	LA; S	6.31	15.33	Infrequent	No	Yes, Endangered – rare and habitat endangered (category 2) 4 records by DW
<i>Staurastrum laeve</i> Ralfs 1848 (Fig. 1e)	Loch Frisa (NM 51080 47026)	MA; D	7.14	7.96	Common	No	Yes, Endangered – rare and habitat endangered (category 2) 2 records by DW
<i>Staurastrum tohopekaligense</i> Wolle 1885 (Fig. 1f)	Loch Shin (NC 56682 07336)	LA; D	6.21	8.96	Infrequent	No	Yes, Endangered – rare and habitat endangered (category 2) 2 records by DW

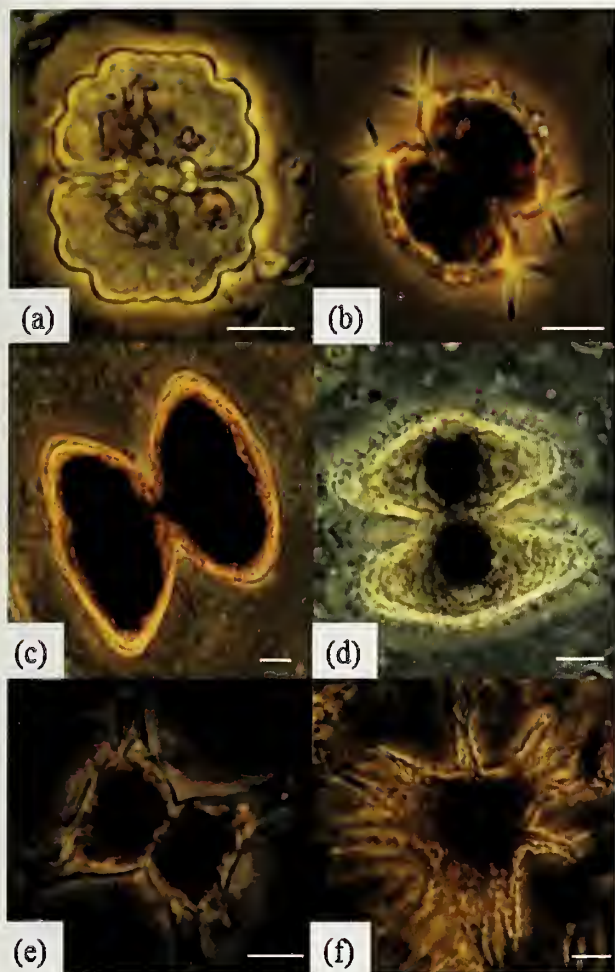


Fig. 1. Photo-micrographs of (a) *Cosmarium dybowskii*; (b) *Staurastrum cornutum*; (c) *Staurastrum grande*; (d) *Staurastrum kouwetsii*; (e) *Staurastrum laeve*; (f) *Staurastrum tohopekaligense* preserved in Lugol's iodine. Scalebar = 10 µm.

When we happen to observe these green wonders of symmetry, mostly in phytoplankton samples collected from oligotrophic to slightly mesotrophic water bodies, an occasional species crops up as a 'chance plankter' (Brook *et al.*, 2011). Adopting an approach that focuses on collecting desmid material from lake shorelines (e.g., squeezing marginal vegetation) would probably reveal more about this particular group of algae than open-water phytoplankton sampling alone. Similarly, blanket mires can be excellent places for spotting desmids, their communities in such habitats often being incredibly species rich (Goodyer, 2013). Secondly, several of the desmid species mentioned here are considered endangered (Brodie *et al.*, 2007; Table 1).

Hence, careful taxonomy is needed to recognise such rare species and documenting their occurrence could help to protect threatened desmid habitats in the future. Lastly, an important point is that the situation is by no means limited to desmids. Algal taxonomy is becoming increasingly renowned as a dying trade (Brodie *et al.*, 2008). Apart from a

handful of us deemed expertly proficient U.K.-wide, there are too few actively hunting for the 'green stuff', even though exciting new finds are waiting to be discovered (e.g., Goodyer, 2013; Lang *et al.*, 2013). This illustrates SEPA's lead role in algae-based assessments of water quality in Scotland, which also generates fundamental knowledge concerning the biodiversity and ecological distribution of algae from the local to national level.

We felt it was worthwhile highlighting the half-dozen uncommon desmids encountered in the phytoplankton of Scottish lochs, which adds value to our statutory work and gives these delightful rarities a well-deserved mention for the British Isles. Through sharing this information, we also hope to spark enthusiasm for this exquisitely beautiful group of algae, encourage others to take to the microscope, and help promote the study of phycology in general: we need more field algologists.

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Hoverfly records from Coll and Tiree (Diptera, Syrphidae)

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INTRODUCTION

There is little published literature on the hoverflies (Diptera, Syrphidae) from the adjacent isles of Coll and Tiree, outermost of the Ebudes (Inner Hebrides). New hoverfly records resulting from visits to the islands of Coll and Tiree in 2010 (Hancock & Robinson) and Tiree in 2012 (Hancock) initiated a search for earlier relevant records. The list below is augmented with previously unpublished data extracted from the Boyd Barr collection held at the The Hunterian (Zoology Museum), Glasgow. Barr collected generally in the west of Scotland and had a particular interest in the genus *Microdon*, populations of which were studied on Mull (Barr, 1995; Schönrogge, *et al.*, 2008). He

resided on Coll for short periods between 1994 and 1996 and collected hoverflies but did not publish details or forward data to the national Hoverfly Recording Scheme so his records were not included in the maps of Ball *et al.* (2011).

Published records from Tiree in Skidmore (2008) were mostly his own observations from 25–29 June 1999. These missed being incorporated in Ball *et al.* (2011) but there are a number of ‘dots’ representing species records from both islands derived from earlier sources. These sources have been identified and so can be included here for completeness. These comprise a list of hoverflies recorded by Joan Childs from The Reef (RSPB Reserve), Tiree in August 2009 and data extracted by Kenn Watt from specimens in the Arthur B. Duncan and Ian C. Christie collections at the National Museums Scotland (NMS), Edinburgh. These specimens are from both Tiree and Coll, captured between 1985 to 1999. Thus the list summarises all available data that have been located on hoverflies from Coll and Tiree.

SPECIES LIST

Nomenclature follows Chandler (1998) with some updates given by Ball *et al.* (2011). Following the arrangement in these two works the species are presented in alphabetical order, due to fluidity in hoverfly higher classification. The collection details are abbreviated and the abbreviations are explained at the end of the species list.

- Cheilosia illustrata* (Harris). **Coll**, Grishipol, 1984 (KW in Ball *et al.*, 2011)
- Dasysyrphus tricinctus* (Fallén). **Coll**: BB1
- Episyrphus balteatus* (De Geer). **Tiree**: 8, [Skidmore]
- Eristalinus aeneus* (Scopli). **Tiree**: 8; **Coll**: BB1, BB2, Meall nan Man, 1984 (KW in Ball *et al.*, 2011)
- Eristalinus sepulchralis* (Linnaeus). **Tiree**: 3, [Skidmore], Hough, 1974 (KW in Ball *et al.*, 2011)
- Eristalis abusivus* Collin. **Tiree**: [Skidmore]
- Eristalis arbustorum* (Linnaeus). **Tiree**: 8, [Skidmore], Hough, 1974 (KW in Ball *et al.*, 2011); **Coll**: 4; BB2, BB4, Meall nan Man, 1984 (KW in Ball *et al.*, 2011)
- Eristalis horticola* (De Geer). **Tiree**: 3, 8, [Skidmore]; **Coll**: BB4
- Eristalis intricarius* (Linnaeus). **Tiree**: 1, 8, [Skidmore], Hough, 1974 (KW in Ball *et al.*, 2011); **Coll**: BB2, Torastan, 1974 (KW in Ball *et al.*, 2011)
- Eristalis tenax* (Linnaeus). **Tiree**: 8
- Eupeodes corollae* (Fabricius). **Tiree**: 1, 8, [Skidmore]; **Coll**: BB1, BB4
- Eupeodes latifasciatus* (Macquart). **Tiree**: 8
- Eupeodes luniger* (Meigen). **Tiree**: 8
- Helophilus pendulus* (Linnaeus). **Tiree**: 5, [Skidmore], Hough, 1974 (KW in Ball *et al.*, 2011); **Coll**: 4, BB1, BB2, BB4, Torastan, 1984 (KW in Ball *et al.*, 2011)
- Helophilus trivittatus* (Fabricius). **Tiree**: 2; **Coll**: BB2

Lejogaster metallina (Fabricius). **Tiree:** [Skidmore];
Coll: BB4
Melanogaster hirtella (Loew). **Tiree:** 4, [Skidmore];
Coll: 1, BB4
Melanostoma mellinum (Linnaeus). **Tiree:** 1, 2, 6, 8,
[Skidmore]; **Coll:** 3, 4, BB3, BB4
Neoscia tenur (Harris). **Tiree:** [Skidmore]
Platycheirus albimanus (Zetterstedt). **Tiree:** 8; **Coll:**
3; BB1
Platycheirus angustatus (Fabricius). **Tiree:**
[Skidmore]; **Coll:** BB4
Platycheirus clypeatus (Meigen). **Tiree:** 1, 8,
[Skidmore]; **Coll:** 1, 2, BB1, BB4
Platycheirus granditarsus (Forster). **Coll:** BB1
Platycheirus manicatus (Meigen). **Tiree:** 3, 5, 6, 8,
[Skidmore], Hough, 1974 (KW in Ball et al., 2011)
Platycheirus occultus (Goeldlin, Maibach & Speight).
Coll: BB1
Platycheirus rosarum (Fabricius). **Tiree:** 5.
Platycheirus scambus (Staeger). **Tiree:** 6,
[Skidmore]
Rhingia campestris Meigen. **Tiree:** 5, 8; **Coll:** BB4
Scaeva pyrastris (Linnaeus). **Tiree:** 8
Scaeva selenitica (Meigen). **Coll:** BB1
Sericomyia silentis (Harris). **Tiree:** 1, [Skidmore];
Coll: 1; BB1; BB4
Sphaerophoria fatarum Goeldlin de Tiefenau. **Coll:**
BB1
Sphaerophoria interrupta (Fabricius). **Tiree:** 8,
[Skidmore]
Sphaerophoria philanthus (Meigen). **Coll:** BB1
Syritta pipiens (Linnaeus). **Tiree:** 1, 7, 8; **Coll:** BB4
Syrphus ribesii (Linnaeus). **Tiree:** 8; **Coll:** BB1
Syrphus vitripennis Meigen. **Tiree:** [Skidmore]
Trichopsomyia flavitarsus (Meigen). **Tiree:**
[Skidmore]; **Coll:** 1.
Volucella bombylans (Linnaeus). **Tiree:** 1, 8; **Coll:** 1,
4, BB1, Torastan, 1973 (KW in Ball et al., 2011)

Abbreviations: BB = Boyd Barr; EGH = Geoff Hancock; JR = Jeanne Robinson; JC = Joan Childs; KW = Kenn Watt.

Tiree localities, 2009-2012:

1. Vaul, 22 August 2012, EGH. Coastal grassland with wet ditches, NGR: NM0449.
2. Balephetrish, 23 August 2012, EGH. Machair grassland behind dunes, NGR: NM0147.
3. Baugh, 22 June 2010, EGH. Fixed dune grassland, NGR: NM0143.
4. Milton, 22 June 2010, EGH. Wet ditches in peat bog, NGR: NM0847.
5. Barrapol, 21 June 2010, JR. Freshwater loch side vegetation, NGR: NL9643.
6. Gott Bay, 22 June 2010, JR. Small area of dunes with tidal ditch, NGR: NM0346.
7. Sandaig, 23 June 2010, EGH, dune grassland, NGR: NL9342.
8. The Reef, August 2009, JC, dune grassland, NGR: NM0045.

Coll localities for 2010:

1. North Shore, 24 June 2010, EGH & JR. Dune grassland and ditches nearby, NGR: NM2763.
2. Cliad Bay, 23 June 2010, JR. Coastal grassland, NGR: NM1960.
3. Ballyhaugh, 22-23 June 2010, EGH & JR. Coastal grassland and freshwater loch, NGR: NM1757.
4. Crossapol, 25 June 2010, EGH & JR. Fixed dunes, NGR: NM 1553.

Specimens collected by JR are deposited at Glasgow Museums Resource Centre, Accession Number Z.2012.2. Those collected by EGH are in The Hunterian (Zoology Museum), Entry Numbers 839 (2010) and 1361 (2012).

Coll localities sampled by Boyd Barr during 1994-1996

These are extracted from specimens preserved in The Hunterian from his collection which was acquired in 2001 (Entry Number: Zoo/35/2001).

BB1. Arinagour, 13 May 1994 - 12 August 1996, NGR: NM2156
BB2. Cornaigbeg, 9-14 May 1994 - 26 July 1995, NGR: NM2362
BB3. Hyne, 27 May 1994, NGR: NM2055.
BB4. Feall Bay, east end, 12-27 June 1994, NGR: NM1454.

COMMENTS

Field work in 2010 and 2012 confirmed 16 of the 22 species from Tiree recorded by Skidmore (2008) and added 9 that were not in his list. Three of Skidmore's that were not seen in Tiree were recorded in 2010 from Coll. From the latter island Barr's collection contains preserved examples of 23 species of which 13 have not been reported by others. Two species, *Cheilosia illustrata* and *Trichopsomyia flavitarsus*, are added to Barr's total. Overall 31 species are listed above from Tiree and 25 species from Coll. None of the species are beyond their known geographical range or found in unexpected circumstances. *Episyrphus balteatus* was absent from our samples in 2010 as the sampling was too early in the season. But it was also not seen on Tiree in 2012, despite it being August, normally the peak month for the species. Curiously, for this common migratory fly, neither are there specimens in Barr's collection. He might not have bothered to preserve examples of this common fly, which is so easily identifiable in the field, but he did keep samples for localities in Mull and other parts in the west of Scotland. Given the close studies he made of *Microdon* (Barr, 1995), it would seem the genus is genuinely absent from Coll.

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BOOK REVIEWS

Alexander Wilson: the Scot who founded American Ornithology

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444 pages, hardback with numerous illustrations.
ISBN 978-0-674-07255-8, \$35

Of the two Scots who made their names as natural historians in North America in the 19th century, John Muir is now well remembered as founder of the Sierra Club and successful campaigner for the establishment of national parks. Alexander Wilson, by no means a lesser figure, remains relatively unknown, at least in his native Scotland. I hope that the events commemorating the bicentenary of Wilson's death and in particular this new book on his life and achievements will help to remedy this situation.

Unlike Muir, who emigrated to the USA with his family when still a child, Wilson moved to America as an adult of nearly 28. He grew up in Paisley, attended school till he was 10, then became a cattle-herder and at 13 an apprentice weaver. In his spare time, he roamed the countryside observing wildlife, especially birds, shooting game for the table, reading widely and honing his writing skills. Robert Burns was a near contemporary, born only seven years before Wilson, and the publication of Burns's first book of poems in Scots (in 1786, when Wilson was just 20) provided a stimulus to Wilson and other young would-be Scots poets to attempt to publish their own verses. Wilson's Poems appeared in 1790, with an expanded, improved version in 1791. Following Burns's *Tam o' Shanter*, Wilson wrote his own epic *Wally and Meg*. Like Burns, Wilson had staunch egalitarian principles and his writings criticising working conditions got him into trouble with the authorities, who were particularly alert to signs of unrest as the French Revolution became more and more alarming to those in power. After more than one spell in jail, Wilson decided to emigrate. With his nephew William, he walked to Portpatrick (heroically long walks are a feature of Wilson's life), took a ship to Belfast and then on to Philadelphia in 1794.

Burt and Davis concentrate on what happened next. The book provides a relatively short account of Wilson's life (chapters 1 and 2, 62 pages) and an assessment of Wilson's poetry remains to be written. The bulk of the book (chapters 3-5, 292

pages) covers Wilson's pioneering work in ornithology.

In the United States, Wilson worked initially as a schoolteacher. His move in 1802 to a school at Kingsessing near Philadelphia was crucial because there he met the American botanist William Bartram who became his natural history mentor. By now, Wilson was observing and drawing birds in their natural habitats and Bartram provided access to his extensive natural history library, allowing Wilson to read what was so far known of American birds. He began to make longer explorations including a two month round trip trek to Niagara Falls (600 miles as the crow flies), and to publish poems and articles in local magazines. He also began a correspondence with Thomas Jefferson who was not only President but also a keen natural historian. In 1806, he accepted the post of assistant editor of an Encyclopaedia being produced by America's foremost publisher of the time, Bradford and Inskeep. This provided Wilson with the opportunity to realise his developing dream, the writing and publishing of an illustrated American Ornithology, the first of its kind. Production of this work, in nine volumes, occupied the rest of Wilson's too short life.

The first volume was published in September 1808. The work was to be financed by persuading people to subscribe to the whole set: this was a nightmare, requiring Wilson to travel extensively to persuade institutions and well-to-do individuals to subscribe. The travels did allow him to see more countryside and more birds, including a heroic 300 mile walk to Pittsburgh followed by 750 miles by rowing boat down the Ohio river to Louisville in Kentucky. In Louisville, he met Audubon and saw some of his bird drawings – Audubon at that time had no plans to publish. Wilson then proceeded south via Nashville and Natchez to New Orleans and then back to New York by ship. By mid 1813, seven volumes had appeared and much material was ready for volume 8. Wilson had been working, travelling, illustrating at a frantic pace and, when he caught dysentery in August 1813, his exhausted body could not respond and he died, only 47 years old. Volume 8 was complete and in production. Volume 9 was finished and published by his friend George Ord in 1814.

Burt and Davis's chapter 3 provides a detailed account of Wilson's work as a bird artist, observer and publisher, highlighting the technical problems of producing such work at that time and also the pioneering nature of Wilson's approach in depicting

birds in natural poses and habitats where possible. The accounts they provide of each set of birds includes Wilson's original sketches, common and scientific names (old and new), a commentary on Wilson's observations and extracts from Wilson's species descriptions. The assembly of this chapter is a formidable piece of scholarship, as are the Appendices which provide a commentary on the sources Wilson referred to and natural historians Wilson corresponded with.

Chapters 4 and 5 provide an assessment of Wilson's place in the history of ornithology and natural history more generally. He was a pioneer in observing largely from nature and in adopting Linnean taxonomy. American Ornithology was the first major work of science produced entirely in the USA. Baron Cuvier, the pre-eminent European anatomist wrote that Wilson has 'treated of American birds better than those of Europe have yet been treated'.

Chapter 5 also includes a detailed account of Wilson's interaction with Audubon and an assessment of why Audubon is better known to the general public, despite the acknowledgement of serious ornithologists that Wilson was the more important scientific figure.

Overall, this is a fascinating book and of interest to anyone who wishes to know about the history of natural history and natural history illustrations. The pictures are splendid and the price modest for a book of this kind.

Roger Downie

Mushrooms

Peter Marren

British Wildlife Collection 1

British Wildlife Publishing Ltd, 2012, 272 pages, hardback with colour illustrations mostly photographs. ISBN 978-0-9564902-0, £24.95

This is the first volume in a new series of books on British wildlife. Interestingly, British Wildlife Publishing have chosen to start the series with fungi. Possibly due to the fact that although there have been several good field guides to fungi in recent years, there are fewer books on the natural history and biology of fungi aimed at the amateur naturalist. With interest in fungi continually increasing, more people require information on the subject, of a broader nature than just name, habitat, edibility etc. and in an easily accessible format.

If this is the aim of the book, then it is a success. Mushrooms packs in a surprisingly large amount of information on a wide range of aspects of fungal biology for its modest 272 pages. This is done by

not going too deeply into any one subject and Peter Marren has been skilful in the quantity of information given being carefully judged to get one interested and to learn enough to be able to move on to more dedicated tomes on topics the reader may find of particular interest.

Nonetheless, text aside, the first thing that hits one as the book is opened is the high quality of the pictures. Although not a field guide, the photographs of illustrated species, taken in the wild, will serve as additional pictorial references to add to those in field guides. Given the variability of fungi, one cannot have too many reference images of species and the photographs are accurate representations. None of the 'surely that's not, species name, oh it probably is' here. Flicking through the pages, species were easily recognised. For example, the distinctive shape and colour of the Goatcheese Webcap, *Cortinarius camphoratus*, on page 87 was immediately recognised from having seen it in Strathblane spruce woods, before noting the caption and without the aid of smell. On page 109 is an outstanding plate depicting various colourful waxcaps. Photographs of these fungi provide some of the most impressive pictures. The printers should be applauded for retaining the accuracy of the colours in the original photographs throughout the book.

There are 13 chapters covering a wide range of subjects. The chapter Meet the Mushrooms gives an overview of the different fungal strategies for survival and reproduction and in the section Predators and Parasites one learns that the Oyster Mushroom, *Pleurotus ostreatus*, supplements its diet of dead trees with small worms.

There follows an informative and occasionally amusing chapter, What's in a Name, which gives insights into what fungal names mean and how they arose with some entertaining anecdotes. Apparently, puffballs were once thought to appear where a wolf had broken wind. Though one would need to consult a more comprehensive work to learn how evidence for this supposition was obtained.

There is a chapter, Mushrooms on Parade, providing an overview of the major groups of mushrooms, arranged in taxonomic order and another on field guides and identification, including some specialist treatments of genera and a discussion of how taxonomic concepts have changed over time. This is followed by one on habitats, which can be important identification criteria. With so many natural history books centred on the southeast, it was good to note that Scottish species, habitats and mycologists get a fair mention in the book - particularly in the section on

mountains. Woods, grasslands, dung and dunes are also discussed.

In *Our Midst* covers fungi we are likely to see in our urban environments. As well as lawn fairy rings, and a terrifyingly true to life photograph of Honey Fungus rhizomorphs, this includes the small bright yellow tropical toadstool which may appear in household plant pots, *Leucocoprinus birbaumii*. Under churchyard conifers one can find the scarce *Amanita inopinata* while the attractive terracotta red caps of *Leratiomyces cereus* (prev. *Stropharia aurantiaca*) are frequent on wood chips, as found on a Springburn Park foray.

A further chapter on why some fungi are rare while others are common, discusses the conundrum of truly rare species (some have only been seen once or a few times) versus species which may be under-recorded for various reasons. The frequency of some species can be affected by changes in climate, habitat, pollution and substrate availability. Others may 'sleep' with several years between fruitings.

There are chapters on fungal foraging, poisonous and edible fungi, the pros and cons of picking mushrooms and a final chapter on endangered species and conservation with tables of action plan species.

Before the index there are numerous references to literature, as well as lists of field guides, websites and mycological organisations.

If there is a gripe, it is that where photographs cover the bottoms of both facing pages, there are no page numbers. Apart from that minor point it is good news. This is a welcome addition to the literature available to naturalists and one hopes will be the first of many.

Robin Jones

Urban Trees: A Practical Management Guide

Steve Cox

The Crowood Press, Marlborough, Wiltshire, 2011, 175 pages, hardback, colour photographs, diagrams in colour and black and white. ISBN 978-1-84797-298-9, £19.99

This is a very useful and comprehensive book for any professional or amateur involved with trees in public or garden spaces. Each chapter deals with particular aspects of trees and the urban environment. The text is accompanied by good photographic illustrations and excellent tabled information from the author's own and others' wide research studies.

In an introduction, the author outlines tree physiology and discusses the undisputed advantages to people of having trees around them in the urban environment. An interesting chapter follows, giving a historical setting to people's interaction with trees around their living spaces. Topics covered thereafter include choice of species of tree for different situations. Size choices too are covered with similar recommendations. Subsequent chapters look at tree establishment, especially problematic in public places and continue to discuss fully maintenance of the mature and maturing tree with all the associated difficulties. All these aspects are comprehensively considered both from the perspective of the tree's problems such as introduced soil, excavations, overhead cables etc., but also the problems and risks trees cause to services, roads and the public generally. Wildlife interactions are discussed too.

Particularly interesting is a chapter on urban tree management and the law (Scotland included). This can be a hot topic for anyone with trees in their garden - or neighbour's garden! Particularly thorny too for anyone involved professionally or otherwise with planning departments. Well worth reading.

As a whole, the book is up to date and conspicuously reflects Steve Cox's many years of experience with trees in the U.K. and abroad. This results in a true understanding of the complexity of giving the urban public the benefits of trees whilst not underestimating the consequent problems. It is as comprehensive a book as I have seen on the subject and should find its way on to the book shelf of planning and road departments as well as landscape contractors and, indeed, the interested public who are at the receiving end of their actions and decisions.

Alison Moss

Guide to Freshwater Invertebrates

Michael Dobson, Simon Pawley, Melanie Fletcher and Anne Powell

Freshwater Biological Association Scientific Publication No. 68, Ambleside, UK. 2012, 216 pages, hardback illustrated with colour and black and white drawings. ISBN 0-900386-80-0, £33

Tom Macan first wrote *A Guide to Freshwater Invertebrate Animals* in 1959. The current guide has been written by staff from the Freshwater Biological Association as a successor to this work and as a tribute to one of the UK's most recognised authorities on freshwater biology, who died in 1984.

Aimed at the established naturalist and those new to the field this book is not intended to be a

comprehensive guide but rather a tool to be used as a first stage in the identification of specimens collected in the field in the British Isles. It provides a useful section on how to take your studies further and ways to contribute to the UK biological recording databases.

Everything about this book is clear and concise. A brief introduction to animal classification, its limitations and the constantly changing state of freshwater systems and their inhabitants helps the reader to understand the challenges faced with the age old practice of identification. Glossary, classification and index sections are easy to follow and well structured.

Like the original publication readers are guided towards an identification in the style of a dichotomous key, but rather than being presented with just two options at each level there can be more, reducing the number of steps to the end point. There are 13 keys, each representing a different group, beginning with a description of the variety of forms, behaviour and developmental stages of the animals to follow. Where appropriate, hand-drawn illustrations are used to help with identification. These are beautifully drawn in great detail and clarity making it a joy to just thumb through the pages even when not being used to make an identification. At the end point, as well as giving, in most circumstances, the family or genus we are also told the number of families/genera and species thus giving you a good idea of how close you may be to an accurate identification.

If there is a negative, then it would be the price. £33 seems a little too expensive. About the £25 mark, I feel, would encourage far more individuals to make a purchase if they are new to freshwater biology or likely to use the guide only occasionally. I think, however, it is a wonderful guide and would certainly recommend it, particularly to those who regularly go out in the field.

Tom Macan would not have been disappointed.

George Paterson

PhotoSCENE 2014

A Natural History Photographic Competition sponsored by Glasgow Natural History Society and the University of Glasgow Institute of Biodiversity, Animal Health and Comparative Medicine.



First equal were two photos, which won £200 each.

Redstart (*Phoenicurus phoenicurus*) from Paul Jerem, taken from a hide in Cashel Woods just south of SCENE on 01/06/2013 using a Nikon D7000 body and Nikon 70-200 mm f/2.8 lens.

A horse fly (*Tabanus sudeticus*) from Richard Sutcliffe, taken in Bearsden, East Dunbartonshire, 19 July 2013 with a Canon EOS 20D and 60mm macro lens.

Second equal were two photos, which won £100 each.

Thrift (*Armeria maritima*) from Sarah Longrigg, taken at Coulport, VC99 on 16/06/2013 using a Canon Powershot A720 IS

Seedling taken by Gillian Simpson with an Olympus E-500 digital SLR and 17.5-45mm lens in the Arima Valley, Simla, Trinidad (5th July 2013).

Third equal were three photos, which won £50 each.

Emerald damselfly (*Lestes sponsa*) by Richard Sutcliffe, taken with a Canon EOS 20D and 60mm macro lens at Comrie, Perthshire, 7 July 2013

Fly agaric (*Amanita muscaria*) by Sarah Longrigg, taken with a Canon Powershot A720 IS on 5 September 2013 at Dalrigh near Tyndrum.

Gannet (*Morus bassanus*) by Jana Jeglinski. An adult Northern gannet (*Morus bassanus*) is temporarily marked with pink paint following the successful retrieval of a GPS telemetry device deployed earlier in the season. The picture was taken on Grassholm, Wales, 6 August 2013 with a Canon Rebel XSi digital camera, Canon 18 - 55mm lens.

Rust and Youth - Grey seal pup (*Halichoerus grypus*) by Martina Maria Quaggiotto, taken with an Olympus digital camera between Cross Park and Pilgrim Haven beach in the Isle of May in late November 2012



PROCEEDINGS 2012

The lecturer's name and title of lecture are given for most meetings as is the location. All meetings were well attended.

10th January

Photographic Night: Members' slides or digital slide shows plus photographic competition results.
Graham Kerr Building.

14th February

Tutorial from John Hume: "Lampreys: love and life (history strategies)". Lecture from Lucy Webster: "Blood, sweat and deer(s): using animal DNA evidence to aid wildlife crime investigation".
Graham Kerr Building.

28th February

82nd AGM followed by a lecture from Jennifer Miller: "Plants: the (real) silent witnesses". Graham Kerr Building.

13th March

Tutorial from Victoria Paterson: "Rodent and parasite dynamics on the islands of Loch Lomond". Lecture from John Murphy: "Why snakes lost their legs: thoughts on the origins of snakes". Graham Kerr Building.

10th April

Tutorial from Keith Cohen: "Bats". Film, 'Taking Root. The Vision of Wangari Maathai. Tree planting in Kenya'. Davidson Building

13th April

Joint meeting with Hamilton NHS held in Hamilton. Lecture from Roy Sexton; "Wild flowers and gardens".

8th May

Tutorial from Anna Muir: "Local adaptation: Scottish frogs in a changing climate". Lecture from Anushka Miller: "Going bald on top: the past, present and future of the Arctic ecosystem".
Graham Kerr Building.

12th June

Summer Social and visit to Lochwinnoch RSPB reserve.

Excursions

19 day excursions and 1 weekend excursion were held throughout the year.

18th September

Exhibition meeting with wine and cheese. Graham Kerr Building.

9th October

"Goodfellow re-visited: the role of microscopy in natural history". Talks and demonstrations by Roger Downie, Geoff Hancock and Richard Sutcliffe.
Boyd Orr Building.

13th November

Lecture from Myles O'Reilly: "Monitoring the fish community in the Clyde Estuary under the Water Framework Directive". Boyd Orr Building.

28th November

Blodwen Lloyd Binns Lecture from Professor Dave Goulson: "How to conserve bumblebees in a crowded world". Graham Kerr Building.

Christmas Dinner followed by a lecture from Graham Law: "Big cat conservation". Graham Kerr Building.

Officers and Council elected at the 2012 AGM Vice Presidents

Bob Gray, Roger Downie, David Palmar

General Secretary

Mary Child

Assistant Secretary

Lyn Dunachie

Treasurer

Susan Futter

Winter Syllabus

Roger Downie

Social Secretary

Avril Walkinshaw

Excursions

Anne Orchardson

Membership Secretary

Richard Weddle

Librarian

Janet Palmar

Assistant Librarian

Pam Murdoch

G.N. Editor

Dominic McCafferty

Newsletter Editor

David Palmar

University Liaison Officer

Barbara Mable

Section Convenors

Richard Weddle Bio-recording

Alison Moss Botany

David Palmar Ornithology

David Palmar Photography

George Paterson Zoology

Councillors

Eilidh Spence

Norman Storie

Morag Mackinnon

BLB Executive

Secretary, Treasurer

Scientific Advisors Peter Macpherson and Roger Downie

Technical advisor Richard Weddle

Financial Advisor Bob Gray

PROCEEDINGS 2013

The lecturer's name and title of lecture are given for most meetings as is the location. All meetings were well attended.

15th January

Joint meeting with Friends of the Glasgow Botanic Gardens for Hopkirk's 'Flora Glottiana' Bicentenary. Lectures from Jim Dickson and Dick Peebles. Boyd Orr Building.

12th February

Photographic Night. Members' photography and results of the photographic competition. Boyd Orr Building.

7th March

Joint meeting with Glasgow University Exploration Society. Glasgow University expeditions report back. Graham Kerr Building.

12th March

83rd AGM followed by a lecture from Mandy Glass: "Dangerous liaisons of animals and their viruses". Boyd Orr Building.

9th April

Tutorial from Chris Cathrine: "Scottish spiders". Lecture from Angus Hannah: "The Natural History of Bute". Graham Kerr Building.

14th May

Tutorial from Richard Sutcliffe and Richard Weddle: "Auditing Glasgow's biodiversity". Lecture from Isla Forsyth: "Hiding in Plain Sight: the work of Hugh Cott, artist and naturalist". Boyd Orr Building

22nd and 23rd June

Conference: 'Natives, Aliens and Reintroductions'. Graham Kerr Building.

Excursions

19 day excursions and 2 weekend excursion were held throughout the year.

17th September

Exhibition meeting with wine and cheese. Graham Kerr Building.

8th October

Tutorial from Alan Silverside: "Looking at Lichens". Lecture from Jeanne Robinson: "Entomological adventures on Mingulay". Boyd Orr Building

10th October

Joint meeting with Glasgow University Zoological Society and Friends of the Earth Glasgow. 'The Black Fish'. A film and discussion on destructive and illegal fishing. Graham Kerr Building.

23rd October

Blodwen Lloyd Binns Lecture. Wallace Centenary Lecture from Professor James Moore: "Making livings: why Darwin and Wallace's theories are worlds apart". Graham Kerr Building.

24th October

Joint meeting with Glasgow University Zoological Society. Lecture from Marianne Fox: "The butterflies of Ecuador". Graham Kerr Building.

12th November

Tutorial from Chris McNerny: "Observations on a colony of adders, slow-worms and common lizards on Loch Lomondside". Lecture from Laura Kubasiewicz: "The Scottish pine marten: using genetic techniques to study an elusive predator". Boyd Orr Building

10th December

Christmas Dinner followed by a lecture from Lief Bersweden: "An Orchid gap year: a 19 year old's

attempt to see every species of orchid in Britain and Ireland in one summer". Graham Kerr Building.

Officers and Council elected at the 2013 AGM

Vice Presidents

Alison Moss
Roger Downie
David Palmar

General Secretary

Mary Child

Assistant Secretary

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Treasurer

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Norman Storie
Gillian Simpson

BLB Executive

Secretary, Treasurer

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Technical advisor Richard Weddle

Financial Advisor Bob Gray

The Glasgow Naturalist

Advice to Contributors

1. The Glasgow Naturalist publishes articles, short notes and book reviews. All articles are peer reviewed by a minimum of two reviewers. The subject matter of articles and short notes should concern the natural history of Scotland in all its aspects, including historical treatments of natural historians. **Before submitting your article please read the detailed Instructions for Authors at: <http://www.glasgownaturalhistory.org.uk/gnat.html>** A summary of the instructions are given below.

2. Full papers should not normally exceed 20 printed pages. They should be headed by the title and author, postal and email address. Any references cited should be listed in alphabetical order under the heading References. All papers must contain a short abstract summarising the work. The text should normally be divided into sections with sub-headings such as Introduction, Methods, Results, Discussion and Acknowledgements.

3. Short notes should not normally exceed one page of A4 single-spaced. They should be headed by the title and author's name, postal and email address. Any references cited should be listed in alphabetical order under the heading References. There should be no other sub-headings. Any acknowledgements should be given as a sentence before the references. Short notes may cover, for example, new locations for a species, rediscoveries of old records, ringed birds recovered, occurrences known to be rare or unusual, interesting localities not usually visited by naturalists, and preliminary observations designed to stimulate more general interest.

4. References should be given in full according to the following style:

Pennie, I.D. (1951). Distribution of Capercaillie in Scotland. *Scottish Naturalist* 63, 4-17.

Wheeler, A. (1975). *Fishes of the World*. Ferndale Editions, London.

Grist, N.R. & Bell, E.J (1996). Enteroviruses. Pp. 381-90 In: Weatherall, D.J. (editor). *Oxford Textbook of Medicine*. Oxford University Press, Oxford.

5. An organism's genus and species should be given in italics when first mentioned. Thereafter the common name is only required. Please use lower case initial letters for all common names e.g. wood avens, blackbird; unless the common name includes a normally capitalised proper name e.g. Kemp's ridley turtle. The nomenclature of vascular plants should follow Stace, C.A. (1997). *The new Flora of the British Isles*, (Second Edition). Cambridge

University Press, Cambridge. Normal rules of zoological nomenclature apply. When stating distribution, it may be appropriate to give information by vice-county.

6. All papers, including electronic versions, must be prepared on A4, double spaced throughout, with margins of 25mm, with 12 point Times New Roman font. Tables and the legends to figures should be typed separately and attached to the end of the manuscript. The Editor can make arrangements to have hand-written manuscripts typed if necessary.

7. Tables are numbered in arabic numerals e.g. Table 1. These should be double-spaced on separate sheets with a title and short explanatory paragraph underneath.

8. Line drawings and photographs are numbered in sequence in arabic numerals e.g. Fig. 1. If an illustration has more than one part, each should be identified as 9 (a), (b) etc. They should be supplied as a high resolution digital image or camera-ready for uniform reduction of one-half on A4 size paper. Line drawings should be drawn and fully labelled. A metric scale must be inserted in photo-micrographs etc. Legends for illustrations should be typed on a separate sheet. Photographs are normally printed in black and white, however the Editor is able to accept a small number of high quality colour photographs for each issue.

9. Articles should be submitted to the Editor: Dr Dominic McCafferty by email dominic.mccafferty@glasgow.ac.uk as a single word processed document. Photographs and illustrations should be high resolution with a minimum of 300 dpi in tif or jpeg format. Please contact the Editor if you require assistance with photographs as in some cases suitable photographs can be obtained.

10. When the article is accepted for publication, the author should return the corrected manuscript to the Editor as soon as possible. Final proofs should be returned to the Editor by email within 7 days. Alterations at this stage should be kept to the correction of typesetting errors. More extensive alterations may be charged to the author.

11. A copy of the published article will be sent to the first author as a pdf file. A paper copy of the article can be provided if requested.

12. All submissions are liable to assessment by the Editor for ethical considerations, and publication may be refused on the recommendation of the Editorial Committee.

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